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A SURVIVAL ANALYSIS OF THE TANKS AND VOIDS ON USS JOHN F. KENNEDY (CV 67) AND USS ENTERPRISE (CVN 65)

by

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A SURVIVAL ANALYSIS OF THE TANKS AND VOIDS ON USS JOHN F. KENNEDY (CV 67) AND USS ENTERPRISE (CVN 65)

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The maintenance of an aircraft carrier's tanks and voids has a direct impact on ship operability and service life. The scheduling of inspections and repair work for these tanks and voids poses a significant problem for the carrier maintenance community. This thesis contributes to refining strategy in the repair planning process by providing the framework for building comprehensive tank and void database files. To demonstrate this, repair history files are constructed for USS John F. Kennedy (CV 67) and USS Enterprise (CVN 65). These files consolidate tank and void repair documentation from the myriad of carrier maintenance agencies and comprise the most complete database for these ships. A similar database can be developed for all the carriers by duplicating this effort. A life cycle analysis of the data reveals that paint coating failure rates are more similar among tanks and voids on the same ship rather than among tanks of the same functional type. A case study for CV-67 examines model accuracy and predicts the expected number of coating failures at a future maintenance period. The lessons learned in this thesis directly supports a follow on study of the JP-5 tanks on the Nimitz class aircraft carriers.

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LIST OF ABBREVIATIONS

APS	Automated Planning System (NNSY database)
CBMP	Condition Based Maintenance Policy
CSMP	Current Ship's Maintenance Project
CD	Cofferdam
COH	Complex Overhaul
COMNAVAIRLANT	Commander Naval Air Forces Atlantic Fleet
CV	Conventionally powered aircraft carrier
CVN	Nuclear powered aircraft carrier
DC	Damage Control (void)
DSRA	Docking Selected Restricted Availability
ESWBS	Expanded Ship Work Breakdown Structure
FO	Fuel Oil (tank)
FOB	Fuel Oil or Ballast (tank)
FOOB	Fuel Oil Overflow or Ballast (tank)
FOS	Fuel Oil Service (tank)
FW BLST	Fresh Water Ballast (tank)
IWP	Integrated Work Package
JB	JP-5 or Ballast (tank)
JCN	Job Control Number
JOB	JP-5 Overflow or Ballast (tank)
JP	JP-5 (tank)
JP Serv	JP-5 Service (tank)
JP-5	Jet Propulsion (fuel)
LC	List Control (void)
MIP	Maintenance Index Page
MLE	Maximum Likelihood Estimate
MPM	Maintenance Planning Manager (PERA)
MRC	Maintenance Requirement Card
MTTF	Mean Time To Failure
NAVSEADET	Naval Sea Systems Detachment
NNS	Newport News Shipyard, Newport News, VA
NNSY	Norfolk Naval Shipyard, Portsmouth, VA
NSTM	Naval Sea Systems Technical Manual
PERA	Planning and Engineering for Repairs and Alterations
PMS	Preventative Maintenance Schedule (3M)
PNSY	Philadelphia Naval Shipyard, Philadelphia, PA
PSNS	Puget Sound Naval Shipyard, Bremerton, WA
RCOH	Refueling Complex Overhaul
SARP	Ships Alteration and Repair Package
SRA	Selected Restricted Availability

SSSF	Supervisor Shipyard San Francisco (Mare Island), San Francisco, CA
SupShip	Supervisor of Shipbuilding
SWB	Seawater Ballast
SWLIN	Ship Work Line Item Number
TYCOM	Type Commander (e.g., COMNAVAIRLANT)
TVDB	Tank and Void Database
TVIM	Tank and Void Inspection Manual
WDC	Work Definition Conference

EXECUTIVE SUMMARY

The maintenance of an aircraft carrier's tanks and voids has a direct impact on ship operability and service life. Current planning and projected force structure call for a fifty year service life for the Nimitz class carriers and has extended the service life of the older conventional fueled carriers beyond original forecasts. Several programs have been implemented by the cognizant carrier maintenance agencies to fulfill fleet requirements. The Carrier Life Enhancing Repairs (CLER) program was instituted by Naval Sea Systems Command specifically to address engineering, repair planning, and reduced maintenance costs. The CLER program is directed by Naval Sea Systems Command Detachment, Planning and Engineering for Repairs and Alterations, Aircraft Carriers (NAVSEADET PERA (CV)). One of the problem areas that PERA (CV) has undertaken within the CLER program is the inspection and repair planning process of the tanks and voids.

Complete documentation of individual tank repair history is paramount to improving the tank and void repair planning process. Developing methods to predict paint coating failure to augmenting current maintenance strategy requires sustained record keeping as well. This thesis provides significant contributions toward these requirements by providing the most comprehensive tank and void paint coating database available for USS John F. Kennedy (CV-67) and USS Enterprise (CVN-65). History files are developed that compile repair documentation retrieved from depot level facilities and PERA archives. A template is produced to build the repair history files that maps out the carrier availability planning and tank work distribution process within the maintenance infrastructure. Using the data gathering methods outlined, similar tank and void databases can be constructed for all aircraft carriers.

A life cycle analysis of the data in the history files is conducted to develop survival functions of the tank and void paint coatings. Comparisons of the tank and void groups on the same ship and between the two ships are made to examine failure patterns. Results of the analysis show that tanks and voids on the same ship have more similar survival functions than those of the same group type between the two ships. CV-67 and CVN-65 are of differing class type and have dissimilar maintenance histories. These observations

pose two important issues towards applying a more structured approach to tank and void maintenance planning. First, it requires that ships be on similar repair schedules to remove the effect of differing repair histories. Secondly, the use and repair history of the tanks and voids on each ship may result in unique failure patterns, particularly when comparing ships of differing class type.

The accuracy of the survival models is tested for the CV-67 tank and voids. Additionally, a demonstration of predicting estimated coating failures to aid decision makers in the repair planning process is provided. USS Kennedy and USS Enterprise are two of the oldest carriers currently in service. A confounding factor limiting the validity of the analysis was the inability to recover repair data prior to 1979. CV-67 was commissioned in 1968 and CVN-65 was commissioned in 1961. By 1979, both carriers had undergone one or more dry docking availabilities, however there is no means of accounting for the extent of tank and void work conducted during those periods. Thus, the details and impact of the unaccountable work are not included in the history files. Consequently, the effect of these missing repairs is over estimation of the coating survival rate, yielding an overly optimistic life cycle.

Positive steps have been by PERA (CV) to acquire historical tank and void repair data using the sources referenced in this thesis. As a direct result of the lessons learned in this thesis, PERA (CV) has endorsed a life cycle study of the JP-5 tanks on the newer Nimitz class aircraft carriers. The study of this critical tank group among ships of the same class removes a significant obstacle in furthering the analysis of tank and void coating failures. The repair histories for this class ship are very similar and the failure data is much more compete. The methods used in this thesis will be applied to that study, currently in progress at the Navy Postgraduate School. The cross-ship comparisons of failure histories for this class may provide productive fleet wide decision criteria in tank and void repair planning. For example, if tanks of the same functional group have similar failure patterns, regular inspection and repair schemes can be developed for the entire class with resources budgeted accordingly. This would be a major step in reducing undesired growth work and unnecessary inspections.

I. INTRODUCTION

The primary mission of an aircraft carrier is to project air power ashore in support of national interests. The ability to sustain carrier presence requires a high degree of coordination within the operations and maintenance infrastructure. For instance, the maintenance of an aircraft carrier's tanks and voids has a direct impact on ship operability and service life. Many facets of ship's operations require the upkeep and functionality of the nearly 1000 tanks and voids dispersed throughout an aircraft carrier. Air operations require the stowage, transfer, and distribution of quality jet propulsion (JP-5) fuel. Flight deck attitude and trim are maintained by floodable ballast and list control voids. Conventional powered (non nuclear) ships are highly dependent on their fuel oil tank capacity. These are just a few of the operations that have an enormous dependence on this intricate network of tanks and voids.

Extensive ship repairs are conducted during maintenance availability periods at a contracted shipyard facility. These availabilities are dynamic and complex processes involving a myriad of both military and civilian agencies. Maintenance availabilities range from four month pier side evolutions to two or three year refueling complex overhauls (RCOH) in dry-dock. Preservation and repair of the tank and void system have become a focal issue in recent carrier availabilities. Rising costs and limited resources necessitate a more structured approach to both maintenance planning and system tracking methods. Management has responded to these limited resources by mandating a conditioned based maintenance policy (CBMP). A CBMP ensures that those systems in most need of repair and with the greatest impact on ship's mission have priority in both planning and allocation of resources. The primary agenda for the maintenance planners is to ensure that the repairs scheduled during these availabilities will fulfill the needs of the fleet through the ship's next operational cycle.

The largest cost element in tank and void repair is the maintenance or replacement of the protective interior surface coating (Scalet, 1996). Adequate corrosion and wear

protection depends on the material condition of the paint coating. Adherence to the CBMP assumes that tank conditions are known, and thus informed work is scheduled; this is not always true. Past availabilities have documented cases where tanks scheduled for re-coating actually have paint coatings that are acceptable for continued service. Conversely, tanks not scheduled for repair but accessed to support other work have been found to have coating failure. Unplanned or new work (growth work) that results from this type of discovery during an availability is performed at a cost two or three times higher than scheduled work.

Current planning and projected force structure call for a fifty year service life for the Nimitz class aircraft carriers and has extended the required service life of the conventional fueled carriers. Several programs have been implemented by the cognizant carrier maintenance agencies to fulfill fleet requirements. The Carrier Life Enhancing Repairs (CLER) program was instituted by Naval Sea Systems Command specifically to address engineering, repair planning, and reduced maintenance costs. The CLER program is directed by Naval Sea Systems Command Detachment, Planning and Engineering for Repairs and Alterations, Aircraft Carriers (NAVSEADET PERA (CV)). One of the problem areas that PERA (CV) has undertaken within the CLER program is the inspection and repair planning process of the tanks and voids.

A. PROBLEM STATEMENT

Two of the oldest carriers in the active duty fleet are the thirty-five year old USS Enterprise (CVN 65), commissioned in 1961, and the twenty-eight year old USS Kennedy (CV 67), commissioned in 1968. Both ships have undergone several extensive overhaul periods in their service life. The focus of this thesis is to analyze the maintenance of the tanks and voids on these two older carriers. To support the analysis, comprehensive history files are developed which consolidate the diverse repair documentation particular to each carrier. These files provide the basis for predicting the number of tanks and voids with paint coating failure.

A typical operational cycle between dry-docking repair opportunities is about sixty months. Cost, manning, operational restrictions, and safety requirements do not allow for the complete inspection of all tanks and voids prior to a scheduled repair period. Therefore, to augment a CBMP it is important that the material condition of tanks and voids are tracked for each ship and that the data gathered be used to predict future failure patterns. This is particularly vital as an aircraft carrier ages through its service life. Older carriers such as USS Kennedy and USS Enterprise have a mix of tanks and voids in various stages of coating life corresponding to different chances of failure through the next operations cycle.

B. LESSONS LEARNED IN PREVIOUS STUDIES

This is the third Naval Postgraduate School thesis on the subject of aircraft carrier tanks and voids. A thorough examination of the scope of the problems inherent in the current maintenance planning methods and procedures can be found in the first thesis by LT Cynthia Womble (Womble, 1994). Womble's thesis stresses the need for an inspection methodology and record system to better track and predict the failure behavior of tank coatings on Nimitz class aircraft carriers (CVN-68 class). She concludes that maintenance planning managers (MPM) are not being provided with the necessary information to make well informed decisions about which tanks to inspect and repair at each ship availability.

Efforts to implement an adaptive planning system in response to rising costs from unplanned growth work are addressed in Womble's thesis. The Tank and Void Database (TVDB) was implemented as a step towards correcting this deficiency. Initial introduction of the TVDB to the fleet was on CVN-65 in 1992, and subsequently added to CV-67 and the Nimitz class as well. Although a fleet-wide master database is maintained at the PERA(CV) offices in Bremerton, WA., it does not include data from sources prior to its inception.

Womble provides background information on transition to the Incremental Maintenance Plan (IMP) that will be used to schedule repair periods for the Nimitz class

carriers. A class-wide repair scheduling policy is possible for ships of the same architectural design. Older carriers (including CV-67 and CVN-65) are scheduled for availability periods based on engineering operating cycles that are more particular to the class type of the ship. Since the Nimitz class carriers comprise the majority of the U.S. carrier fleet, the maintenance community is very interested in developing a class-wide tank and void repair plan that can be supported by the IMP. As CVN-65 and the conventional fueled carriers (CV-63, CV-64, CV-67) reach the end of service life within the next fifteen years, the Nimitz class will be the sole aircraft carrier type in U.S. naval service.

The second Naval Postgraduate School thesis on this topic, by LT Mark Thornell (1996), characterizes aircraft carrier tanks and voids by function, failure mode, deck location, and liquid volume contained. He then stratifies the tanks and voids into groups and assigns criticality factors to each group reflecting the relative impact of tank failures on ship's operations. Thornell's stratification scheme is used in this study to separate each ship's tanks and voids into functional groups which provide the basis for compiling the repair data for analysis.

Thornell also develops a preliminary inspection decision model based on each group's criticality factor, coating failure characteristics, and cost of inspection and repair. The results of his model shows the cost of intermediate inspections between docking availabilities lower overall lifecycle costs compared to the costs that are currently realized with an infrequent inspection system. Primarily, cost savings are realized when inspections are more frequent because the planning managers will have better foreknowledge of the tanks and voids in the planning stage of the availability instead of during the availability. This greatly reduces the occurrence of expensive new or growth work.

Thornell was able to develop survival functions for coating lifetimes of Nimitz class carriers using the TVDB. His analysis comparing the tank and voids indicates that the coating failure rates of the groups are different. For the newer Nimitz class carriers that have not yet had an extended docking availability, the TVDB can provide a reasonable record of tank activity. The older Nimitz class, (CVN-68,69,and 70), however,

have had several docking availabilities and overhauls prior to 1990. Since the TVDB does not contain a record of these repair periods it cannot be used as the sole reference for developing a life cycle study of the paint coatings. This fact is even more evident for CV-67 and CVN-65.

C. SCOPE OF THESIS

Expanding on the TVDB to develop a composite record of tank repairs for older carriers requires a knowledge of the maintenance infrastructure. The PERA office in Bremerton, WA maintains a library of aircraft carrier availability documentation. This library was thoroughly searched as an historical resource for tank and void overhaul data for CVN-65 and CV-67. Visits were made to the major shipyards to interview tank inspectors and planners. From historical records and interviews, missing tank and void overhaul data was tracked down. The following chapter discusses the means of tracking tank and void repair within the maintenance network and the impact this network has toward developing a life cycle study.

Chapter III gives the specific details and assumptions that were made in developing the repair history files for each carrier. While both ships are aircraft carriers, they are not of the same class. The USS Enterprise is the first nuclear powered aircraft carrier and is unique from the Nimitz class nuclear carriers. USS Kennedy is the last built conventional fossil fuel powered carrier and thus its hull design differs from that of a nuclear carrier. The differences in hull design create varying functionality in the tanks and voids.

Chapter IV addresses selection and estimation of survival functions based on the data contained in the history files to model the tank and void coating lifetimes. Survival functions are compared between ships as well as between tank groups of the same ship.

Chapter V provides an example of using the survival functions to estimate the expected number of tank coating failures for CV-67 between availability periods. In addition, the accuracy of the estimated survival functions is compared to actual tank coating failure history of CV-67. Chapter VI summarizes the study and provides recommendations.

II. TRACKING TANK AND VOID MAINTENANCE

A comprehensive tank and void maintenance program requires a chronological record of the tanks that are opened and the results of those inspected. Each tank history should document repair as well as paint dates. To date, there exists no centralized database for tank and void maintenance that consolidates repairs from all availability periods across each ship's service life. This fact has impeded developing a life cycle failure analysis of the various tank and void groups from historical data.

Failure analysis of the paint coatings requires identifying tank and void repair work to the individual tank level. Tracking maintenance and repair of individual tanks is extremely difficult. Since the tank and void repair documentation are so widely dispersed along each ship's history, it is essential to develop a roadmap to localize possible sources of data. This chapter documents the progression of events through an availability period, from administration and planning to distribution of work. Breaking the process into stages allows the identification of repair opportunities and historical coating failure data. It is intended that this documentation not only serve as background for CV-67 and CVN-65 history files, but that it also provides a template for constructing similar history files for other carriers.

A. BACKGROUND

Aircraft carriers are built at Newport News Shipbuilding (NNS), located in Virginia. NNS also serves as one of the dry docking shipyards for the Atlantic Fleet along with Norfolk Naval Shipyard (NNSY) in Portsmouth, Virginia. Ships often transfer fleet assignments within their service life, as in the case of USS Enterprise which has transferred from the Pacific Fleet to the Atlantic Fleet. The age of the data sought, and the distribution of shipyards where carrier availabilities are performed confound tracing historical repair data. In addition, Base Realignment and Closure (BRAC) has resulted in a number of public shipyards closing. Among these are Philadelphia Naval Shipyard

(PSNS) and Mare Island Naval Shipyard. Decreased shipbuilding and downsizing of the US Navy force structure along with economic competition has resulted in consolidation in the private sector as well. The sole remaining shipyard that can facilitate a carrier docking availability on the Pacific coast is Puget Sound Naval Shipyard (PSNS) in Bremerton, WA. With each homeport change and shipyard closing, records and institutional knowledge of carrier maintenance are lost.

Aircraft carrier maintenance availabilities fall into three general categories: selected restricted availability (SRA), docking selected restricted availability (DSRA), and complex overhauls (COH). Tank and void paint coating overhaul (grit blast and re-coat) usually requires the ship to be in a dry docking availability period. This limits the majority of actual overhaul work of tanks and voids to the DSRA and COH availabilities. SRA periods can be effectively used to inspect the tanks and voids and schedule those found in need of repair at a subsequent docking period. Each carrier has a planning yard for these availabilities; for example, the planning yard for CV-67 is NNSY, and the planning yard for CVN-65 is PSNS.

B. TANK AND VOID MAINTENANCE PLANNING

Administration and funding of aircraft carrier maintenance resides with the fleet Type Commanders (TYCOM). This billet is filled by Commander Naval Air Forces Atlantic (COMNAVAIRLANT) and equivalently (COMNAVAIRPAC). Since active duty military personnel periodically rotate assignment, it is necessary to have a long term civilian component in the maintenance network to keep system expertise and provide continuity with the repair facilities. NAVSEADET PERA(CV) fills this role.

Figure 1 illustrates the tank and void maintenance planning process. Discrepancies found through ship's force and independent contractor inspections are input into the onboard Current Ship's Maintenance Project (CSMP) database via a form 4790.2K ("two-kilo") submission. The results of these inspections should be recorded in the TVDB as well. Tank and void work candidates come from authorized work requests (AWR) that are generated based on the CSMP and the TVDB. As a carrier approaches an upcoming

availability, representatives from the ship and planning agencies hold a work definition conference (WDC) to asses and screen work requirements.

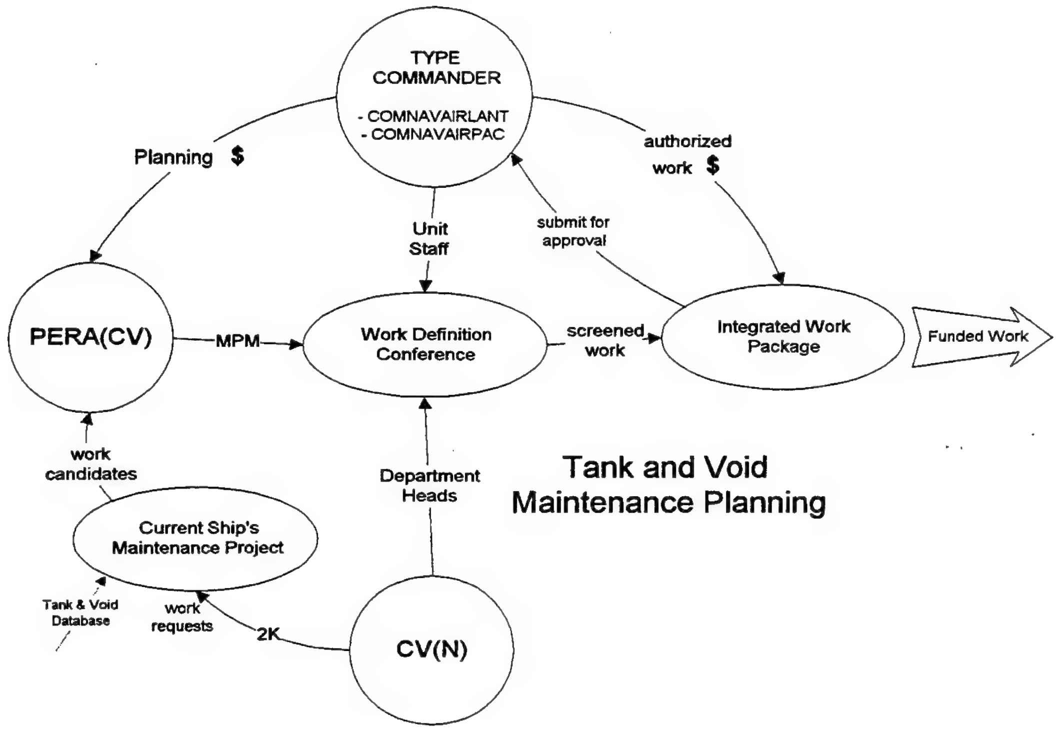


Figure 1. Tank and Void Maintenance Planning Stage.

Each carrier has a representative MPM from PERA that is essentially a liaison between the ship, TYCOM, and the repair facilities. MPM(s) generally come from Navy backgrounds and thus bring a great deal of experience and tenure to the process. The MPM and the unit representative from the TYCOM staff coordinate the WDC to determine which work is necessary and feasible in the availability and which work will be deferred. The CBMP then prioritizes work and alterations.

The effectiveness of this planning process is impaired when there are no documented history on the tanks and voids or no means of predicting the number of coating failures. Often, the status of a tank or void, and the degree of repairs to be conducted is unknown until it is accessed in the availability. This "open ended" method of repair planning is inefficient and costly. Vital budgetary dollars will be spent inspecting

tanks that are satisfactory while other failures will be missed. Other tanks will be found to have coating failure and have to be deferred or result in growth work conducted at a higher expense.

The MPM submits an Integrated Work Package (IWP) to the TYCOM for funding and approval of planned work screened through the WDC. The authorized IWP is the contractual document between the TYCOM and the shipyard for the work to be performed in the upcoming availability. Once the IWP has been authorized and approved, the work can be contracted out to the maintenance repair agencies.

C. DISTRIBUTION OF TANK AND VOID REPAIR

Figure 2 maps out the distribution of contracted tank repairs within the shipyard. It also provides insight into why a one-source comprehensive database has been difficult to establish. Cognizance of tank and void history is not centralized but distributed among the large number of military and civilian agencies involved. For example, the majority of repairs for CVN-65 since it transferred to the Atlantic Fleet in 1990 has been conducted at both public and private shipyards: PSNS and Mare Island, which are public shipyards, and SupShip San Francisco (SSSF), a private facility.

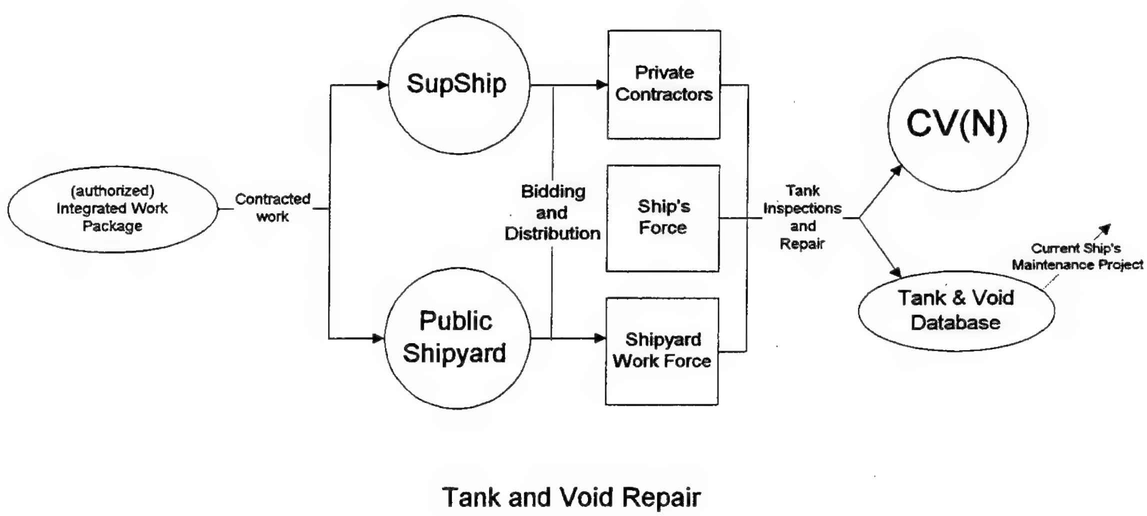


Figure 2. Distribution of tank and void work inside the shipyard.

During availabilities at private shipyards, maintenance may be contracted out, via the Supervisor of Shipbuilding (SupShip) to private contractors. In the case of a public shipyard, the work may be distributed between the public shipyard's workforce and private contractors if the shipyard cannot fully support the maintenance. Ship's force routinely provide "touch up" repairs and will paint tanks and voids that do not require grit blasting. The fact that the work has been so diffuse has prevented developing a repair tracking system that aids the planners in efficiently planning and scheduling tank and void work.

D. CONFOUNDING FACTORS IN TRACKING TANK AND VOID DATA

Methods of compiling tank and void work accomplished have only recently been established. Once the data are found, characteristics of the repair documentation and work accounting methods must be understood. Knowledge of these elements is central to discriminating actual tank and void coating failures and overhaul work within repair documentation. Additionally, issues that impact data collection capabilities must be considered.

1. Documentation and Accounting Issues

Work is aggregated in the IWP under the Expanded Ship Work Breakdown Structure (ESWBS) or Ship's Work Line Item Number (SWLIN). This accounting system lists work to be performed at the system level by estimated man-hours and estimated cost aggregated over the system, not by individual component. In the context of tanks and voids, the resolution of work description is generally at the functional group level (e.g., JP-5, fuel oil). Specification of work and costs down to the component level (for this study, the individual tank) is held with the unit performing the actual work. For example, if the shipyard organization does the work then the information resides in the tank work package at the shipyard. Citing actual tank work packages from ten or more years back is not possible. Additionally, recovering work reports completed by private contractors is not possible.

IWP(s) do not necessarily reflect the actual work performed in the availability. During the course of the dry docking period, scheduled maintenance may be canceled, deferred until a subsequent availability, or revised due to new or growth work. Although the IWP is a contractual reference between the TYCOM and the shipyard, the docking period and the document itself is dynamic. Completion IWP and Departure Reports are to be generated by the shipyard to account for actual work performed at the conclusion of an availability. These documents are not available or do not exist in many cases. Even when these documents do exist, they rarely itemize work performed below the system (SWLIN/ESWBS) level. For example, rather than list each individual tank these documents usually aggregate costs by referencing a particular Job Control Number (JCN). The JCN contains the reference to the tank work packages that detail the maintenance performed. Resolving this issue returns to the individual tank work packages which are rarely kept long term.

Tank and void material condition repairs may vary in scope. Repairs may range from a complete grit blast and re-coat, to a smaller level of preservation such as a re-coat or touch up. The lack of detail in many repair documents makes establishing a baseline for coating failures difficult. Additionally, the level of preservation will have significant impact on the coating lifetime of a renewed tank.

2. Data collection issues

The depot facilities have no mandate to provide long term storage of maintenance records for tanks and voids. Within the PERA organization, the ship's planning manager is responsible for the whole ship; tanks and voids are just one system among hundreds. Personnel turnover causes a loss of valuable historical knowledge at every link in the military - civilian maintenance network. Since military personnel rotate to new assignments every few years their knowledge does not even extend across sequential availabilities. Shipyard inspectors, planners and painters retire, promote, or transfer to different departments. If a shipyard database exists (e.g., Automated Planning System

(APS) at NNSY), the contents of each database only reflects maintenance since program inception. Data from work contracted outside the shipyards is completely untraceable.

Central to PERA's approach to the data collection problem is that intrinsically (aboard ship) tanks and voids are not treated as a single system. Ownership of the various functional groups is delegated to the departments that operate them. For example, the fuels division (V-4) controls the JP system tanks while the damage control department maintains the damage and list control voids. Shipboard installation of the TVDB is intended to correct the lack of standardization in record keeping practices between departments, as well as between ships. Unfortunately, the TVDB has not been utilized to its potential, and many shipboard inspection results still go unrecorded.

The result of such a convoluted network and dissemination of responsibility is one of the major reasons that there still does not exist a composite database of tank and void work. This chapter has addressed the tank and void maintenance process. The specifics of developing the history files for each carrier are given in the next chapter.

III. DEVELOPING HISTORY FILES

The categorization of tank and voids developed by Thornell (1996) is used in this study to partition the tanks and voids into separate functional groups. The commonality of fluid volume contained within these functional group provide a basis for structuring the history files. Four history files are developed for CVN-65 and three files for CV-67. The first two files for each ship contain records for the JP-5 (jet petroleum) and fuel oil (standard diesel marine) tank groups. Each tank group is comprised of the entire population of tanks that hold a particular fluid. For instance, the JP tank group contains; JP-5 service (JP serv), JP-5/Ballast (JB), and JP-5 Overflow/Ballast (JOB) tanks. The fuel oil tank group is similarly defined. The third file for both carriers combines the damage control (DC) and list control (LC) voids into a single group. CVN-65 Dry void and cofferdams are also aggregated into a common group. There is not sufficient data to support a study of the dry voids and cofferdams on CV-67.

It is reasonable to assume that the coating failure rates of the groups are different since they are coated with different types of paint and contain different fluids. The JP tanks are undoubtedly the best maintained because of their high priority to an aircraft carrier's operational mission. Preventive Maintenance Scheduling (PMS) mandates periodic inspections of this group, thus they are closely monitored and routinely maintained. In addition, the JP-5 tanks are coated with a paint that has a zinc additive, which inhibits galvanic corrosion. In contrast, voids are painted with a high build epoxy and do not have as stringent a PMS requirement.

The fluid type also affects corrosion rate. JP-5 and fuel oil are petroleum products and are thus natural preservatives. A tank maintained full of JP-5 or fuel oil is not subject to a corrosive environment. However, many tanks are filled with sea water for ballast as their volume is depleted. Sea water is highly corrosive due to the high free chloride content. Seawater compensation, as a practice, in JP system tanks was stopped in the 1980’s to preclude problems with fuel contamination and material corrosion. The JP

system is still subject to contamination from external sources such as replenishment from auxiliaries. Because of this, JP tanks are routinely sampled and stripped of contaminants. To maintain quality, JP-5 fuel from storage and ballast tanks pass through a purifier prior to transfer to service tanks. Additionally, fuel delivered to aircraft refueling stations pass through a filter assembly. As a final check, a sample is drawn from the aircraft fuel tanks and checked for any form of contamination (particulate or seawater) after fuel delivery. List control voids maintain a transient level of sea water as a matter of function. DC voids may supplement the list control voids for gross attitude and trim control or alternatively may be left dry. Ships use the DC voids differently, depending on design and class type. Dry voids and cofferdams are subject to corrosion due to moisture and condensation. Finally, the possible exposure to contamination due to leakage from adjacent compartments is a factor in the corrosion of the paint coating.

A. HISTORY FILE BASIS

The PERA Manday Summary provided in Appendix A.1 provides the starting point for tracing repair history through the maintenance network. This document spans each ship's service life and lists the where, when, and quantity of tank and void work performed during availability periods. Each ship must be considered individually because of different service age, home-port assignments, planning yards, and repair history. The majority of tank and void overhaul work is conducted at a depot level (shipyard) facility. Documentation of repair work and accounting procedures vary among the shipyards, particularly between the private and a public shipyards. The sources and references used to develop each ship's history files are given in Appendix A.2. Data collected at the PERA library and from shipyards were cross-checked for consistency and compared to data available in the TVDB. The accumulation of these sources comprises the most exhaustive effort currently available towards developing a comprehensive database.

The history files by group for each ship are provided in Appendix A.3 through A.9. The majority of CV-67 repair availabilities where conducted at NNSY with the

exception of the 1993 COH which was conducted at PNSY. CVN-65 has a diverse history across both the Atlantic and Pacific Fleets. Early availabilities were conducted at PSNS and through Supervisor of Shipbuilding San Francisco (SSSF) as listed in Appendix A.1. Upon transfer to the Atlantic Fleet in 1990, repair availabilities have been conducted at NNS.

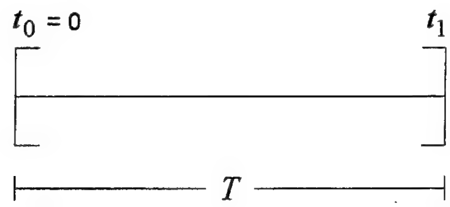
B. HISTORY FILE STRUCTURE

By consolidating the historical repair documentation for each ship into a comprehensive data file a substantially improved record keeping system is attained. As new data are added the files can be readily updated in standard spreadsheet format. To conduct a life cycle or trend analysis the coating lifetimes must be interpreted from the data. The structure of the data files allows for the chronological extrapolation of these lifetimes. Coating failures are found by comparing the known conditions that are specified at the times annotated in the history files. Tank and void coating failures that are found at scheduled inspections fall into censoring intervals.

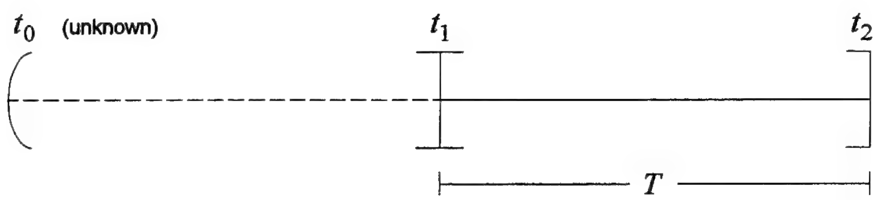
1. Determining Censoring Intervals

Let age t_0=0 represent the beginning of a tank coating lifetime upon initial painting or subsequent grit-blast and re-coat. Initial painting refers to the ships entry into fleet service (commissioning). The actual age (t_f) when coating failure occurs for a particular tank is not known. Failure ages are either right, left, or interval censored. A tank or void is inspected or entered for some reason at time (t_1) and its condition noted. If the tank coating is discovered to have failed at t_1 and the then the precise age of failure cannot be ascertained. The coating failure age is said to be left censored at age t_1 or equivalently censored into the interval $[0, t_1]$. The tank may not be entered again for several years (t_2) to update its status. If the tank coating has subsequently failed within $[t_1, t_2]$, then again a precise failure age cannot be ascertained beyond the censoring

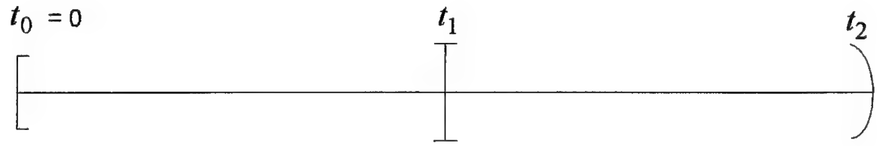
interval. Right censoring occurs when a tank has not failed over the service life of the ship, or has not failed since its most recent overhaul. The coating failure age is then right censored coincident to its age at the most recent inspection. Because repair and inspection periods are scheduled at fixed times, failures often fall into the same censoring interval. Further details of life data censoring classifications are found in Nelson (1982). Example line drawings illustrating the data censoring types are provided in Figure 3(a-c).



(3a). Example of an interval censored coating failure. In this instance, the age at which paint coating failure T occurs can only be resolved to be in the interval $[0, t_1]$. Note that if a tank has had a coating failure and subsequent re-coat then coating age will not be the same as ship age.



(3b). There are many tanks and voids that have multiple recorded inspections. The coating failure was satisfactory at t_1 and found failed at a later inspection t_2. Similar to the first example, the coating failure age can only be resolved to be in the interval $[t_1, t_2]$. In this instance the tank history is untraceable prior to t_1, and the most optimistic assumption with respect to failure rate is that $t_0 = 0$.



(3c). There are also many tanks that are right censored at the coating age corresponding to their last inspection. In this instance the tank coating was found to be satisfactory at t_1 as well as t_2.

Figure 3(a,b,c). Common Censoring Intervals found in Tank and Void Paint Coating Failure Data.

2. Summary Interval Charts

Figure 4 summarizes the history file for CV-67 fuel oil tanks by depicting the number of tanks that failed within an interval or similarly the number that were still satisfactory at the end of the interval (right censored). For example, Interval 1 indicates that 17 tank coatings failed between the tenth and sixteenth year of service life [10,16], with no failures before the tenth year based on inspection history. Interval 5 depicts 3 tanks that were inspected at the ship's age of twenty-five years and found to have good coating condition. Since the coatings on these three tanks have no recorded history of failure in the twenty-five year service life of the ship their lifetimes' are right censored (suspended) at age 25 years.

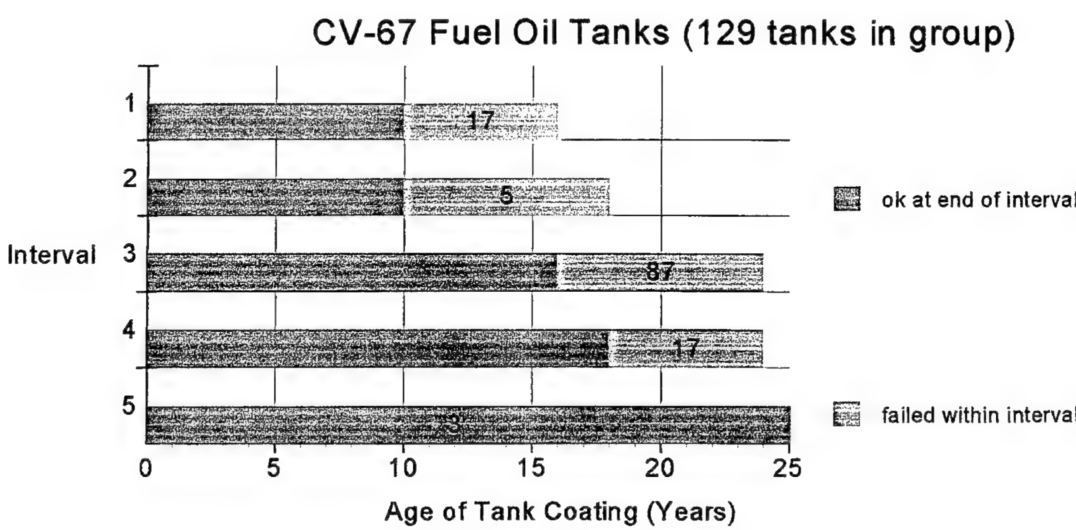


Figure 4. Summary Interval Chart of the CV-67 fuel oil tank group.

It is possible for the number of failures to exceed the number of tanks in the group. This occurs when tanks of a group have more than one recorded coating failure. Similar summaries for the remaining history files are located in Appendix B.1 for CV-67 and Appendix B.2 for CVN-65. The intervals illustrated in these summaries are used for estimation of coating lifetime survival functions in the next chapter.

3. Assumptions Made in History Files

a. A coating failure is assigned to a tank if the results of an inspection listed in the TVDB for the tank top, bottom, and sides average condition 3 or higher. TVDB entry format is given in Womble (1994) per the Tank and Void Inspection Manual (TVIM) by Wheeler (PERA, 1993).

b. In all cases, if a source document indicates that a tank was overhauled then the coating is considered to have failed.

c. The length of the censoring intervals for groups are different based on functional criticality. As an example, JP-5 tanks have the highest priority thus criticality. The JP-5 fuel system has the most restrictive Preventative Maintenance System (PMS) requirements of all the tank and void functional groups (MIP 5420 MRC 18M-5/36M-3, October 1995). The result is that time between successive inspections and hence the censoring intervals tend to be smaller than those of other groups. Generally, it is assumed that overhaul of JP-5 tanks that have been found to have coating failure is done at the next docking availability. Deferment beyond the upcoming dry docking availability may limit or preclude use of the tank and is therefore assumed not to occur. See NavSea Technical Manual (NSTM 542) for material and quality control requirements.

d. For Damage and List Control Voids, if a failure is indicated, the censoring interval is taken to be the age of the void between the time failure was noted and the last COH. These floodable seawater voids have high priority on the ship. It is reasonable to assume that if there is no indication of repair at the previous COH then its coating must have been in satisfactory condition at that time. This assumption is

consistent with the PMS requirement for the inspection of all Ballast Tanks and Floodable Voids as at least once every seven years (MIP 1230 MRC 84M-1, September 1995) See NSTM 074 for material control requirements.

e. MIP 1230 MRC 24M-2/48M-1, February 1988 directs the inspection of fuel oil service tanks every twenty-four months and fuel oil stowage tanks at least once every forty-eight months . Similar to the DC & LC void group, the censoring interval is taken to be the age of the void at the last COH to the age of the tank when the failure was detected. This assumption is made if there is no other documentation to support a smaller censoring interval. The criticality of the fuel oil tanks is different on the two ships reflecting the major difference in their propulsion systems.

f. No assumptions are made about the dry void and cofferdam group since they have a low criticality factor and are inspected infrequently. The censoring intervals on this group tend to be the largest due to infrequent inspection and the scarcity of documented history. In many instances the coating lifetimes are right censored, in this case suspended at the current service life of the ship or last documented inspection.

4. CV-67 File Specifics

The CV-67 group history files contain repair code legends at the top of the first page for each group. Specifying actual work performed is possible for maintenance availabilities of 1983 and later because of supporting documentation. As annotated in Appendix A.2, NNSY supplied their Advanced Planning System (APS) database for this study. The APS database details actual work package instructions for work to be accomplished. Additionally, a copy of the PNSY Tank and Void Status and Work Report for the 1993 COH was obtained. This document gives a full description of actual work performed by tank number. Further comments on CV-67 file structure follow:

a. If the APS documentation does not list significant work on a tank group for an availability period, then that period does not appear in that group's history

file. For example, the 1989 SRA is listed in the CV-67 fuel oil tank group file but not in the JP-5 or DC & LC file.

b. The last inspection date and condition are taken from the TVDB and cross-referenced to the results listed in the PNSY Tank and Void Status and Work Report documentation.

c. Specific documentation, by availability, is listed in Appendix A.2.

5. CVN-65 File Specifics

The level of detail in CVN-65 availability documentation allows specifying which tanks where overhauled within the docking period. It does not contain the level of detail in the work breakdown structure as given in the NNSY APS database for CV-67. Documentation of sources is given in Appendix A.2.

a. The last inspection date and coating condition are taken from the TVDB and cross-referenced to sources listed in Appendix A.2 for 1990-1994 RCOH.

b. A comments section is included in the history files (Appendix A.6 - A.9) to indicate a specific reference used to make a determination on a particular tank. In addition, important assumptions in determining the censoring intervals or other pertinent information is included in the comments column.

c. Fuel oil tanks on CVN-65 are not as critical as they are for CV-67 since it operates a nuclear propulsion system. At the last RCOH (1990-1994), the fuel oil tanks on CVN-65 were converted to higher priority JP-5 stowage tanks.

C. HISTORY FILE LIMITATIONS

No documentation could be found within the PERA library or within the shipyards that documents tank and void work performed prior to 1979. Cost accounting by ESWBS is itemized by man-days expended and material cost. The PERA man-day summary (Appendix A.1) clearly shows a significant level of tank work prior to 1979. Initial attempts to aggregate the man-days and approximate the number of tanks

overhauled during an availability period were unproductive. For instance, man-days expended during an availability divided by the average number of man-days to overhaul a tank approximates the number of tanks overhauled in the availability. Consistent and reliable estimates of the average man-days expended to overhaul a tank could not be attained. This restricts identification of coating failures to those recorded 1979 or later. Approximations based on average man-day expenditures for pre-1979 availabilities are not included in the final version of the history files. A further problem that greatly restricts inclusion of failures based on non-itemized man-days is the inability to segregate overhaul expenditures from other non-overhaul type repairs. Estimating the average number of overhauls requires the assumption that all man-day expenditures are for overhaul work. This is not a valid assumption. Additionally, the data do not suggest a consistent ratio that can be applied to the expenditures to extract overhaul from non-overhaul repairs.

With the lack of documentation on tank and void history prior to 1979 the history files are constructed under the assumption that no failures occurred between commissioning and 1979. This is a necessary, but optimistic approach to accommodating the data available for these two older carriers. It is optimistic because it effectively "allows" a coating to be older than it really is in instances where the tank had a prior coating failure and overhaul but no documentation exists. This effect is most pronounced in tanks that have coating ages that are suspended (right censored) at the full service age of the ship. With the exception of the dry void and cofferdam group, tanks and voids with coating ages suspended at the age of the ship must be considered somewhat suspect in that regard.

The degree to which this lack of documentation impacts the analyses can be gained by looking at the PERA man-day expenditure summary. Pre-1979 coating and overhaul work corresponds to the first ten years of the USS Kennedy's service life. Several significant expenditures (4368 man-days) are listed in the summary that are not accounted for in other documentation. For USS Enterprise, which is an older ship, 1979 marked the eighteenth year in service life. The PERA man-day expenditure summary lists significant

pre-1979 work (12074 man-days) in tank and void groups and the impact will be more pronounced.

A further obstacle that prevents including pre-1979 work is the advances in paint coating technology. PERA has instituted programs to reduce corrosion rates using galvanic corrosion inhibitors, improved polymer epoxy paint coatings, and better paint application techniques. The goal of these programs is to increase the mean time to failure (MTTF) in the tank and void paint coatings thus providing a longer service life. Differences in MTTF due to changes in coating technology cannot be accounted for across the historical data for non detailed work expenditures.

The impact of not incorporating pre-1979 coating failures and extending the censoring intervals to ship's commissioning date will cause the estimated survival functions to over approximate actual coating lifetimes. This must be kept in mind when drawing conclusions from the study, as discussed in the next chapter.

IV. ANALYSIS

The repair history files are structured such that the coating lifetimes can be ascertained. Each tank or void has its own history that may contain zero, one, or several coating renewals over the span of the ship's service life. The summary interval charts then provide the means of aggregating the coating failures within a group of tanks or voids. This format lends itself to conducting a lifecycle analysis of the data and provides the opportunity to model the survival functions. In this chapter, survival functions are estimated for each group of tanks and voids based on these summary interval charts. The formulation to estimate the expected number of coating failures within an interval is developed for application in the next chapter. Cross-ship and same-ship comparisons of survival functions for these groups are discussed, which provide insight into the validity of prior assumptions, and give direction for future study. For example, an important result that can be obtained from this analysis is whether tanks and voids of the same functional type have similar coating failure patterns across different ships, or if the failures are better characterized by each ship's particular maintenance history.

A. MODELING FAILURE DATA

There are a variety of methods available to aid in choosing a particular parametric probability distribution to model failure data. Standard goodness of fit tests can be used if the defining characteristics of the data are unknown or the model is to be chosen *a priori*. Alternatively, if experience or history suggests a particular distribution, statistical methods are available to estimate model parameters. Probability distributions commonly used to model life and failure data include: exponential, normal, lognormal, and Weibull. Each of these distributions possesses properties that capture characteristics inherent in the failure data.

Properties most often compared in reliability studies are the survival function and the failure or hazard rate. The survival function is the probability that an item is

functioning at any time *t*, whereas the failure (hazard) rate provides a measure of risk associated with an item at time *t*. Generally, as a component or system ages with time it will become more susceptible to failure as it wears. Therefore, the structural and material engineering sciences require a probability distribution with a failure rate that increases with product age to model material corrosion or wear-out processes. The exponential distribution, with the "memoryless" property, has a constant failure rate and therefore is rarely applicable to these types of problems. The normal and Weibull distributions however can model data with an increasing failure rate. The lognormal distribution has a failure rate that increases initially and then decreases. Lognormal may be applicable to wear-out type problems if failures occur early in life, or distribution parameters are such that a lognormal is relevant over the range of the data. The lognormal does have the advantage that all possible outcomes (lifetimes) are positive. The normal distribution has a strictly increasing failure rate but can have negative lifetimes. This may be a problem if the mean lifetime is not sufficiently far from zero or greater than three times the standard deviation (to preclude negative outcomes). An alternative is to use a truncated normal distribution to remove the possibility of negative lifetimes. Nelson (1982) states that the popular distribution among engineers is the Weibull distribution, and recommends trying it first in fitting lifetime failure data.

The Weibull distribution has the advantage of being extreme flexibility in empirically fitting data because it has a great variety of shapes. Outcomes from the Weibull are all positive, and both increasing and decreasing failure rates can be modeled. The Weibull distribution has been found to be the most applicable for modeling wear-out type failure, particularly when applied to the strength of materials. These characteristics of the Weibull make it very popular among engineers, and is a sound choice for modeling the tank and void coating failure data. A brief summary of Weibull distribution properties as detailed in Nelson (1982) is provided in Appendix C.1.

B. METHODOLOGY

The survival functions modeled by the Weibull distributions should capture the trends in the coating failures for each group of tanks and voids. The shape of the distributions is determined by value of the model parameters. Since the actual value of the parameters that define the Weibull distributions are unknown, they must be estimated from the data. The accuracy of the models in representing the failure data can only be as good as the quality of the data allows. The classic statistical method of estimating probability distribution parameters is the method of maximum likelihood (MLE). Detailed MLE theory and the Newton-Raphson technique used to estimate the covariance matrices for the Weibull parameters can be found in Nelson (1982). Maximum likelihood estimation for calculating the Weibull model parameters for the tank and void data is now developed.

1. Maximum Likelihood Estimation of Weibull Model Parameters

Let tank lifetimes be represented by the random variables; $X_1,\ldots,X_N$, lifetimes are independent and identically distributed with distribution F and survival function $S = 1 - F$, parameterized by $\theta_1,\theta_2,\ldots\theta_k$. Maximum likelihood estimation (MLE) is used for estimating model parameters for all groups. In the case of interval and right censored data, the likelihood function (L) can be expressed as:

$$L(\theta_1,\theta_2,\ldots\theta_k) = \prod_{i=1}^{M}\{F(u_i) - F(l_i)\} \prod_{i=M+1}^{N} S(l_i),$$

where the observations are ordered so that X_i are censored into the interval $[l_i, u_i]$ for $i = 1,\ldots,M$ and right censored at l_i for $i = M+1,\ldots,N$. Thus, the first M observations represent tanks that have failed between inspections with corresponding age u_i and l_i respectively. The remaining observations represent those tanks that have survived through their last inspection period and are right censored at l_i, their age at the most recent inspection. The two parameter Weibull has scale and shape parameters (λ,κ).

Maximizing the likelihood function or equivalently the log likelihood function requires a numerical solution. Maple (Waterloo Maple, Inc.) was used to find the MLE $(\hat{\lambda},\hat{\kappa})$ for the two parameter Weibull, with the Newton-Raphson method to obtain Fisher's observed information matrix. The Maple source code for these solutions is given in Appendix C.2. An example illustrating the log likelihood function in the vicinity of the shape and scale estimates is given in Figure 5.

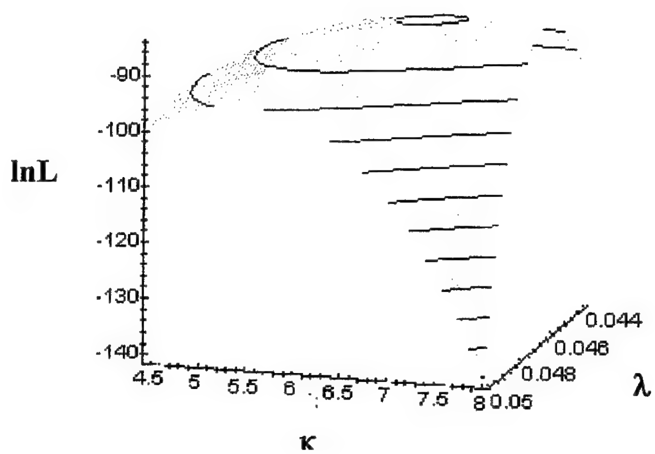


Figure 5. CV-67 Fuel Oil Tank Group log likelihood function. Log likelihood (lnL) is plotted against the two Weibull parameters (λ,κ).

The set of log-likelihood contour plots for all groups by ship are contained in Appendix C.3. These contour plots show the likelihood function is highly sensitive to the scale parameter λ. On the other hand, the log-likelihood is relatively flat over a wide range of κ, indicating that the variance of $\hat{\kappa}$ is large.

2. Estimating Confidence Regions for λ, κ

Let $\mathbf{b} = (\hat{\lambda},\hat{\kappa})'$ be the vector of estimated parameters, and similarly let $\beta = (\lambda,\kappa)'$ be the vector of the true parameters. A joint (1-α) 100% confidence region for β is given by (Greene, 1990):

$$\{\beta : F_{1-\alpha,2,r-2} \geq \frac{1}{2}(\mathbf{b}-\beta)'(\hat{\mathrm{Var}}[\mathbf{b}])^{-1}(\mathbf{b}-\beta)\},$$

where $F_{p,n,m}$ is the p^{th} quantile of an F - distribution with n and m degrees of freedom and $\hat{\mathrm{Var}}[\mathbf{b}]$ is the inverse of Fisher's observed information matrix obtained in calculating the MLE. The number of degrees of freedom used in this case is: $n = 2$, the number of estimated parameters, and $m = r - 2$, the number of coating failures within the group minus the loss of two degrees of freedom from the estimated parameters. Here α represents the level of significance desired in obtaining the confidence region and should not be confused with the Weibull parameter for characteristic life, which is also often designated as α. Example source code and illustration of the 95% joint confidence regions are provided in Appendix C.4.

C. SURVIVAL FUNCTIONS

Estimated survival functions and hazard rates developed using the Weibull models are plotted in Appendix D for both CVN-65 and CV-67 groups. Figure 6 provides an example of these plots for the fuel oil tank group. The reliability (survival) function, and failure (hazard) rate are plotted over the expected fifty year service life of an aircraft carrier. In each graph, the black line is the function using $(\hat{\lambda},\hat{\kappa})$ the estimated values of (λ,κ). The blue line plots the survival function using the lower bound for κ and the upper bound for λ from the joint 95% confidence regions. Similarly, the red line plots the survival function using the upper bound for κ and the lower bound for λ. As illustrated in Figure 6, the combinations of (λ,κ) give a worst case (blue line) and a best case (red line) scenario for tank reliability prior to the characteristic life $\left(\alpha = \frac{1}{\lambda}\right)$.

CVN-65 Fuel Oil Tanks: $\hat{\lambda} = 0.0317$, $\hat{\kappa} = 2.40$, **Mean Life = 27.96 years**

95% Confidence Intervals:

$$[0.0289 \leq \lambda \leq 0.0345]$$

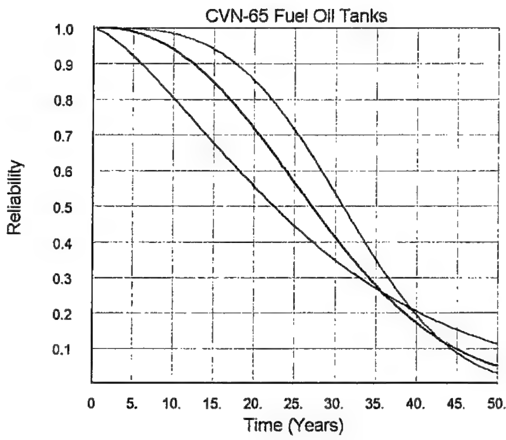
$$[1.43 \leq \kappa \leq 3.36]$$

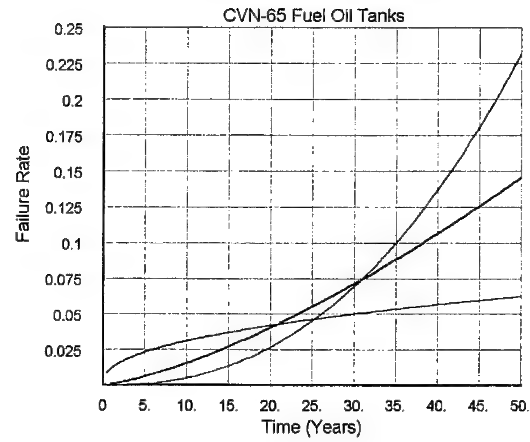
Two parameter Weibull plots

$\lambda = 0.0345$, $\kappa = 1.43$

$\lambda = 0.0317$, $\kappa = 2.40$

$\lambda = 0.0289$, $\kappa = 3.36$





CV-67 Fuel Oil Tanks: $\hat{\lambda} = 0.0468$, $\hat{\kappa} = 6.91$, **Mean Life = 19.97 years**

95 % Confidence Intervals:

$$[0.0453 \leq \lambda \leq 0.0483]$$

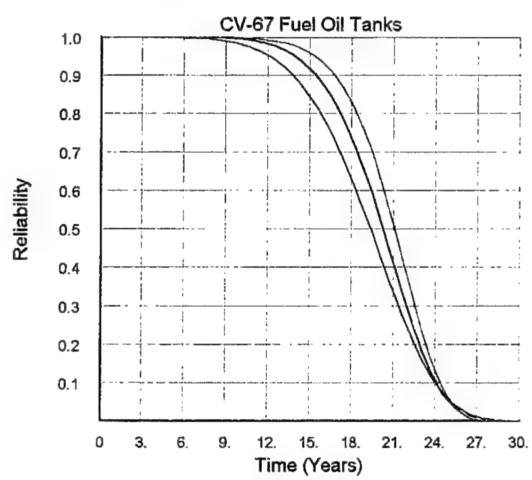
$$[5.55 \leq \kappa \leq 8.27]$$

Two parameter Weibull plots:

$\lambda = 0.0483$, $\kappa = 5.55$

$\lambda = 0.0468$, $\kappa = 6.91$

$\lambda = 0.0453$, $\kappa = 8.27$



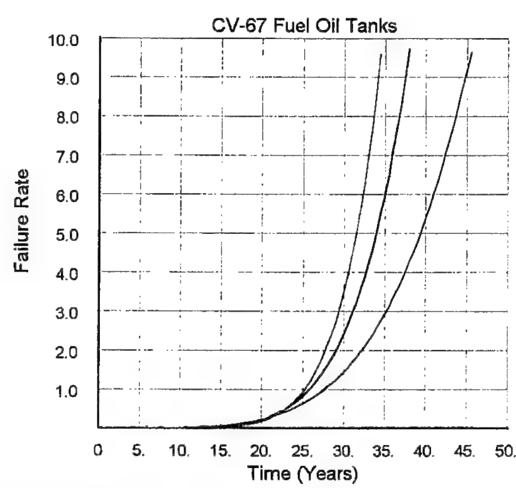


Figure 6. Survival function and failure rate plots for the fuel oil tanks.

The plots in Figure 6 reveal the influence the shape parameter has on the reliability and failure rate for the Weibull distributions. Comparing the combinations of parameter estimates, a large shape parameter initially gives a higher reliability and a lower failure rate. However, the failure rate increases more rapidly with a larger shape parameter. In the vicinity of the mean coating life the failure rate with the higher shape parameter will exceed that with the smaller shape parameter. This eventually causes the survival function with the larger shape parameter to be less than the one with a smaller shape parameter. This can be seen in Figure 6 by the crossover of the red and blue lines.

The accuracy in the estimated parameters for the Weibull models is only as good as the span of the censoring intervals. As the time between recorded inspections decreases the length of the censoring interval decreases as well. The actual age at which coating failure occurs can be more closely resolved as the censoring interval decreases. It follows then that the Weibull parameter estimates will be more accurate, and better reflect the survival functions as these censoring intervals become tighter. For many of the intervals depicted in the summary charts in Appendix B.1 and B.2 the time between recorded inspections is ten or more years. A ten year censoring interval represents a very uncertain determination from the data as to when failure occurred.

The assumptions outlined in the previous chapter detail how the data are interpreted in determining the length of the censoring intervals. These assumptions result in optimistic survival functions because coating failures are not assigned unless they could be verified. Preliminary analyses show that increasing the precision of the interval, by decreasing the uncertainty as to when failure occurs causes the shape parameter to increase and its estimated variance to decrease. This is consistent with the intuitive sense that as the width of the censoring interval decreases, the higher the failure rate is in the vicinity of the interval. Uncertainty is minimized by making the censoring interval widths as small as possible. Conversely, if the censoring interval is large, the shape parameter will be low since that the chance of failure must be distributed throughout the interval. This accuracy of the model parameters and hence the ability to predict coating lifetimes

underscores the need for a composite tank and void database encompassing all of the ship's service life.

D. ESTIMATING THE EXPECTED NUMBER OF FAILURES IN AN INTERVAL WITH CONDITIONAL SURVIVAL FUNCTIONS

Once the survival functions have been determined the conditional survival functions and expected number of failures within an interval can be estimated as well. The uncertainty in the predictions caused by the variance in the survival functions and positive dependence among the coating failures is considered. The formulation for these functions are developed here and applied in the next chapter.

1. Conditional Survival Function

Paint coatings within a particular group of tanks have varying ages. Tanks with older coatings will be more likely to fail in the next operational cycle than those that have been painted more recently. Let T represent a tank coating lifetime; then the conditional survival function, $S_{T|T\geq a}(t)$, as defined in Leemis (1995), is the survival function of an item to age t that is functioning at age a:

$$S_{T|T\geq a}(t) = \frac{P[T \geq t,\ T \geq a]}{P[T \geq a]} = \frac{S(t)}{S(a)}, \quad t \geq a.$$

Thus the conditional survival function has the same shape as the remaining portion of the unconditioned survival function at time t, but is rescaled by the factor $S(a)$.

2. Estimating the Expected Number of Coating Failures

The expected number of failures between maintenance cycles are estimated from the conditional survival functions. For the i^{th} subset of N_i tanks in a particular group with the same coating age a_i, the expected number of tank coating failures between (a_i, t_i) may be expressed as;

$$\mathrm{E}[X(a_i,t_i)] = N_i(1 - S_{T|T\geq a_i}(t_i)).$$

Here, t_i is the age that tanks in the i^{th} subset will be if they survive to the end of the interval. Summation over all subsets within a group yields the total expected number of tank failures in that group;

$$\mathrm{E}[X] = \sum_i \mathrm{E}[X(a_i,t_i)].$$

Further summation across all groups for the ship will give the total expected number of tank and void failures between docking repair availabilities.

The variance of the predicted number of failures is found with the assumption that the $X(a_i,t_i)$ are independent and follow binomial distributions. Thus, the variance of the prediction for each group may be found by summing:

$$\mathrm{Var}[X] = \sum_i \mathrm{Var}[X(a_i,t_i)] = \sum_i N_i \hat{S}_{T|T\geq a_i}(t_i)(1-\hat{S}_{T|T\geq a_i}(t_i)).$$

The standard deviation is the square root of the variance.

These standard deviations are biased low for two reasons. They do not take into account the variance of the estimated survival function and more importantly they are biased on the assumption of independence of coating failures between tanks. It is plausible that tank coating failures are positively dependent. Dependence in tank coating failures may be realized in the observation that overhaul repairs are frequently scheduled in clusters about the ship. Although Thornell (1996) addresses tank location in his stratification scheme, this attribute has not yet been significantly studied to quantify its significance to the tank and void problem. Clustering of repairs may be purely an aggregate scheduling device employed in the current planning process (i.e., repairing sections of the ship at a time) because other parts of the ship may be inaccessible for other reasons. Conversely, the clustering of repairs in a section of the ship may indicate that tank failures are related to location. Since it is infeasible to inspect all tanks within an availability due to the large number and resource limitations, quantifying the dependence in coating failures based on environmental or physical location factors is difficult.

The increased variance in the binomial assumption due to positive dependence will cause the prediction estimate to be less certain. Long term, thorough record keeping that tracks coating failures and overhauls will better distinguish the degree of positive dependence. Correlating area failures among ships of the same physical design type (i.e., Nimitz class) may provide valuable insight to the significance of the location factor.

E. COMPARISONS

Comparisons can be drawn regarding the survivability of like functional groups across the two carriers. The question of interest in these comparisons asks, "are the coating lifetimes in tanks of the same group modeled by a common survival function?" For example, if observed lifetimes from CV-67 JP-5 tanks can be modeled by the same distribution parameters as the JP-5 tanks on CVN-65, then there are potential fleet-wide implications regarding scheduling their repair. In this study, the two carriers are of different class type, but nonetheless the comparisons may be considered relevant towards developing inferences on the tank groups at the functional level. Alternatively, comparisons among tank groups of the same ship may be made that more closely examine tank usage and repair history factors that are specific to each ship.

1. Methods for Comparing Survival Functions

Lee (1992) provides methods for two sample comparisons of Weibull distributions. Initially, it is sufficient to test whether the shape parameters are significantly different $\left(\mathrm{H_o}: \kappa_1 = \kappa_2\right)$. Two sample shape parameter tests are conducted using the F test, or equivalently the confidence interval for κ_1 / κ_2:

$$\left[\frac{\hat{\kappa}_1}{\hat{\kappa}_2} F_{1-\alpha/2,2r_1,2r_2}, \frac{\hat{\kappa}_1}{\hat{\kappa}_2} F_{\alpha/2,2r_1,2r_2} \right],$$

where r_1 and r_2 are the number of failures in the first and second sample respectively. If the interval contains one, then the null hypothesis that the shape parameters are the same cannot be rejected. If this hypothesis is rejected, it is not necessary to test the scale parameters and it can be concluded within the tested significance that the distributions are not the same. If the hypothesis test for the shape parameters is not rejected then further tests are required.

The Weibull++ software package (ReliaSoft, Inc. 1994) was used to test the hypothesis on the shape parameter. The test uses the statistic $\hat{p}$, which is the estimate of $P(X > Y)$, where X and Y are independent random variables from each of the two Weibull distributions. The algorithm used by Weibull++ to compute $\hat{p}$ was developed by Brown and Rutmiller (1973). For Weibull distributions with the same shape parameters, a $P(X > Y) = 0.50$ implies the two distributions are the same.

2. Cross-ship Comparisons

Tables 1 and 2 summarize the estimated model parameters for the group survival functions by ship. From these tables the cross-ship and same-ship comparisons will be made.

Group	$\hat{\lambda}$ [95% CI]	$\hat{\kappa}$ [95% CI]	Estimated Mean Life (years)
Fuel Oil Tanks	0.0468 [0.0453 , 0.0483]	6.91 [5.55 , 8.27]	19.97
JP-5 Tanks	0.0465 [0.0409 , 0.0521]	1.70 [1.24 , 2.16]	19.19
Damage & List Control Voids	0.0406 [0.0380 , 0.0432]	2.00 [1.22 , 2.79]	21.83

Table 1. CV-67 Estimated Parameters with 95 percent confidence intervals (CI).

Group	$\hat{\lambda}$ [95% CI]	$\hat{\kappa}$ [95% CI]	Estimated Mean Life (years)
Fuel Oil Tanks	0.0317 [0.0289 , 0.0345]	2.40 [1.43 , 3.36]	27.96
JP-5 Tanks	0.0334 [0.0327, 0.0341]	2.36 [2.17 , 2.55]	26.53
Damage & List Control Voids	0.0342 [0.0330 , 0.0354]	1.48 [1.04 , 1.92]	26.44
Dry Voids & Cofferdams	0.0333 [0.0331 , 0.0335]	4.66 [3.85 , 5.47]	27.46

Table 2. CVN-65 Estimated Parameters with 95 percent confidence intervals (CI).

Hypothesis tests at a five percent level of significance are tabulated in Table 3. The Weibull++ software package fails to reject the null hypothesis that the distributions are the same for $0.4 \leq \hat{p} \leq 0.6$. From Table 3 it can be seen that the difference in shape parameters for the fuel oil groups is so large that it is immediately inferred the two models are different. For the JP-5 group the resulting confidence interval for $\kappa_{CV\text{-}67} / \kappa_{CVN\text{-}65}$, $[0.536, 0.950]$, is close enough to one to merit the second test. The second test for model comparison using the Weibull++ software was used and the conclusion was the two models for the JP-5 groups are different, ($\hat{\lambda}_{CVN\text{-}65} = 0.0334$, $\hat{\lambda}_{CV\text{-}67} = 0.0465$). Table 3 shows that the shape parameters for the DC void group are the most similar of the three groups. The conclusion for the DC void comparison is that the failure distributions for the two ships are not significantly different.

			Initial Test	2nd Test	
Groups compared	$\kappa_{CV\text{-}67}$	$\kappa_{CVN\text{-}65}$	F-Test interval	$\hat{p}$	Conclusion
Fuel Oil	6.91	2.40	reject (2.04, 4.18)	-------	different
JP-5	1.70	2.36	don't reject (0.54, 0.95)	0.68	different
DC Voids	2.00	1.48	cannot reject (0.95, 1.85)	0.55	same

Table 3. Results of Two Sample Comparisons (Cross-ship).

Cross-ship comparisons of like groups listed in Tables 1 and 2 show that CVN-65 mean lives are greater than those on CV-67 in all cases. Since the two carriers are of different classes, one nuclear and one conventionally powered, we would expect their group survival functions to reflect operational and functional differences. The most dramatic difference is in the fuel oil group that most characterizes the structural differences in the two carriers. The mean life of CV-67 fuel oil tanks is eight years less than CVN-65 and has a much higher failure rate. This illustrates the functional differences in the way the ships use these tanks. The fact that CV-67 would have a greater usage for fuel oil tanks is characterized in that group's survival function. In fact, CVN-65 uses fuel oil tanks only to fuel other ships in the carrier battle group, thus its volume is less transient, resulting in less seawater contamination. As a result of the low priority fuel oil tanks on CVN-65, the tanks were converted to highly critical JP-5 storage tanks at the last COH.

3. Same-ship Comparisons

The comparisons of groups on the same-ship yield survival functions that are much more similar than cross-ship. Mean life for CV-67 groups average 20.33 years and mean life for CVN-65 groups average 27.10 years. Thus average group mean lives are very similar within the same ship but differ by seven years across ship. This observation supports the conclusion that the use and maintenance history of the tanks and voids on each ship may result in unique failure patterns. This may be particularly true for ships of different class type. Undoubtedly these estimates are high as a result of the inability to include pre 1979 repairs, giving an overly optimistic survival rate. This effect is more pronounced in CVN-65 group means because by 1979, USS Enterprise had undergone several major availabilities which had included significant tank and void work. It can be reasonably assumed that the inclusion of the pre-1979 repair data would lower the group means within ships as well as cause the group means between ships to be more similar.

F. SUMMARY

Coating failures will be most likely be found during a maintenance period, regardless of the group. Therefore, all tank coating failures are clustered about the intervals corresponding to these periods, particular to each ship, causing mean tank lives to be similar within tank groups on the same ship. There are important implications of this result for the data analysis. To minimize the influence of differing repair histories, comparisons should be made between ships on similar repair schedules. For example, the newer Nimitz class aircraft carriers follow a much more structured repair schedule under the Incremental Maintenance Plan (IMP), in which the operational cycles between maintenance availabilities will be the same for all ships. Thus the intervals between inspections for the tank and void groups will be similar for ships of the Nimitz class. An analysis of the tank and void coating failures on the Nimitz class will provide a better indicator of whether coating failures are unique to each ship or are group/location related.

Ultimately, the goal in the systematic progression of these studies is to give guidance to decision makers in determining maintenance strategies for the tanks and voids. The next chapter provides an example application of the CV-67 tank and void survivor functions as a predictive tool in estimating the expected number of coating failures at future availabilities.

V. CV-67 CASE STUDY

The methodology developed in the last chapter is now used to analyze tank failures for each functional group and to evaluate a proposed repair schedule. Having a predictive tool to estimate the number of tank failures can provide a great benefit in both short term and long term repair planning. In the short term, resources (dollars, time) needed for each tank and void group for the next docking period can be approximated. In the long run, the distribution of tank and void failures over the lifetime of the ship can be estimated under various maintenance schemes. These estimates can be used by the planning agencies to schedule repair and inspections.

In this chapter use of the survival functions is demonstrated for CV-67. The accuracy of the survival functions are checked against the known group histories to compare how well the models fit the data. Although the missing data and the resulting assumptions necessary to construct the history files limits the accuracy of the models, the demonstration shows the value of pursuing these predictive methods. The availability schedule obtained for CV-67 from PERA(CV) as of October 1996 lists a DSRA in October 1999 (2000) and a COH in January 2002. The expected numbers of tank coating failures by group are calculated in the interval between the last availability (1994 COH) and these next two docking periods. These computations take into account the most recent observed condition of each tank.

Since USS Kennedy is beyond the midway point in her service life, alternative options can be considered. In particular, maintenance planners will want to know how many tanks to fix and when to plan to repair them. Cost considerations and the need to maximize the impact of budgetary dollars encourages minimizing the number of overhauls late in service life. A reasonable question for the planners to ask is, "What are the chances that tanks that are overhauled survive the remainder of ship's service life?" Ideally, a tank overhauled late in service life will last until the ship is decommissioned. Some hypothetical repair scenarios are examined and these issues addressed. End of

service (EOS) for USS Kennedy is approximated as 2008 based on a forty year service life for conventional fueled carriers.

A. CALCULATING CONDITIONAL SURVIVAL PROBABILITIES

The formulation for the conditional survivability function developed in the last chapter is referenced to calculate the estimated survival probability. For example, in 1994 there are three fuel oil tanks that are of age $a = 25$ years. To survive to the next DSRA in year 2000, these tanks need to survive past age $t = 31$ years. Thus, the chance that a tank in this group will survive to the next DSRA is estimated by:

$$\hat{S}_{T|T\geq 24}(31) = \frac{S(31)}{S(25)} = \frac{2.10 \times 10^{-6}}{5.20 \times 10^{-2}} ,$$

where $\hat{S}$ is the estimated survival function for the fuel oil group found in the previous chapter.

The summary charts in Figure 4 and Appendix B give the various lifetimes of tanks within a group. Within each summary chart are intervals containing tanks with surviving paint coatings of varying ages (a_i). Table 4 provides the conditional survivability calculations for each interval.

						DSRA at year 2000		COH at year 2002	
Group	Interval (i)	Age (a_i) at 1994	No. Tanks N_i	Percent of Group	$\hat{S}(a_i)$	Age (t_i)	$\hat{S}_{T\|T\geq a_i}(t_i)$	Age (t_i)	$\hat{S}_{T\|T\geq a_i}(t_i)$
Fuel Oil	1	25	3	0.023	0.052	31	0.00	33	0.00
JP-5	2	9	40	0.610	0.80	15	0.73	17	0.64
	3	15	4	0.061	0.58	21	0.66	23	0.56
	4	25	7	0.106	0.27	31	0.58	33	0.47
DC/LC	5	9	26	0.464	0.84	15	0.73	17	0.63
	6	25	7	0.125	0.25	31	0.48	33	0.36

Table 4. Conditional survivability calculations for paint coatings surviving at age a_i. Results for the next two dry docking periods are tabulated, [1994,2000] and [1994,2002].

From Appendix A-3 it can be seen that the remaining 126 of the 129 fuel oil tanks currently have tank coating failure. An immediate conclusion from Table 4 is that the

remaining three fuel oil tanks that are twenty five years old in 1994 will likely fail in the period [1994, 2000]. We note that it is important to condition on the last known age of the tank. For example, the conditional survivability of a JP-5 tank to fifteen years given that is has survived nine is estimated by $\hat{S}_{T|T\geq 9}(15) = 0.73$, where as the estimated unconditional survivability is $\hat{S}(15) = 0.58$. By not taking into account the time a tank has survived, the chance that the tank will survive until the next availability is substantially underestimated.

B. CALCULATING THE EXPECTED NUMBER OF COATING FAILURES AT AN AVAILABILITY

Conditional survival probabilities calculated in Table 4 are used in Table 5 to give the estimated expected number of failures for each interval class that contain surviving tanks. Values are listed for the next two repair availabilities.

		DSRA at year 2000		COH at year 2002	
Group	Interval (i)	Estimated $E[X(a_i,t_i)]$	Estimated $E[X]$ $\pm$ std deviation	Estimated $E[X(a_i,t_i)]$	Estimated $E[X]$ $\pm$ std deviation
Fuel Oil	1	3.0	3.0 ± 0.0	3.0	3.0 ± 0.0
JP-5	2	10.8	15.1 ± 5.0	14.4	19.9 ± 5.3
	3	1.4		1.8	
	4	2.9		3.7	
DC/LC	5	7.0	10.6 ± 3.6	9.6	14.1 ± 3.8
	6	3.6		4.5	
Estimated expected failures $\pm$ std deviation		28.7 ± 8.6		37.0 ± 9.1	

Table 5. Estimated expected number of coating failures of tanks over the period (a_i, t_i).

Table 5 shows that 28.7 tanks are expected to have coating failure in [1994,2000], with an additional 8.3 coating failures in [2000,2002]. The estimated expected number of failures at the year 2002 COH for the fuel oil group is lower than expected because there is no further accumulation in failed fuel oil tanks. A graphical summary of the results

tabulated in Tables 4 and 5 are provided in Figure 7. Coating failures at the 1994 COH represent the actual number of known failures within each group at that time.

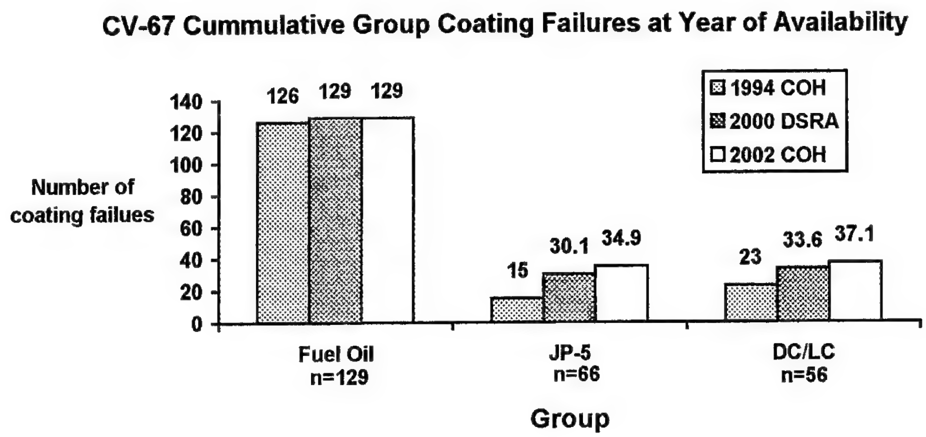


Figure 7. Summary coating failure chart for CV-67 groups.

It is important to recognize that the number of coating failures shown in Figure 7 for the year 2000 DSRA and 2002 COH are predictions. The actual number of coating failures that occur in the operational cycles till these future availabilities will not be precisely these values. The uncertainty in the prediction estimates caused by the variance in the estimated survival functions and positive dependence in the coating failures must be kept in mind when viewing Figure 7.

C. MODEL ACCURACY

The estimated number of failures from the fitted Weibull models are now compared to the actual number of failures to check the Weibull modeling assumption. Comparisons are best done at those times for each group which represent a significant trend in the lifetime data. The comparison of the estimated to actual number of paint coatings to survive beyond twenty-five years is highlighted. These comparisons are reviewed for each group:

1. CV-67 Fuel Oil Tanks (129 tanks in group)

From Figure 4, of 129 tanks in this group, all survive beyond the ten year mark. Seventeen fail in [10,16], five fail in [10,18], eighty-seven fail in [16,24] and seventeen failures occur in [18,24]. Three tanks survive beyond twenty-five years. Figure 8 graphs the associated actual and estimated number of tank coatings that survive through the represented intervals:

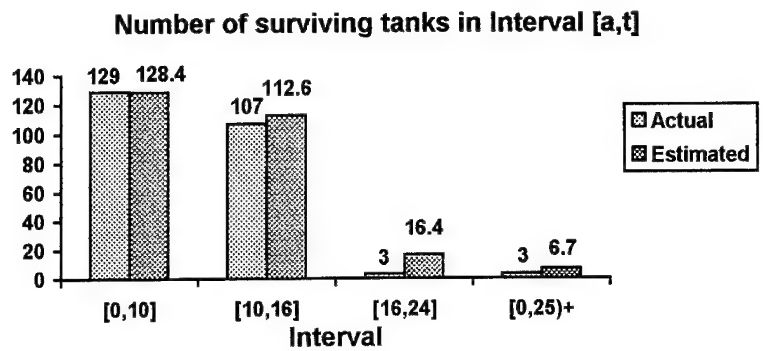


Figure 8. Comparison of Actual vs. Estimated surviving tank coatings for the fuel oil tank group.

For this group the estimate of the number of tanks to survive beyond twenty-five years is 6.7 which over estimates the actual number of survivors (3). The survival rate estimated by the Weibull model appears to be optimistic beyond the mean life (21.8 years), but generally appears to capture the trends in the failure data.

2. CV-67 JP-5 Tanks (66 tanks in group)

This group has tanks with multiple lifetimes. The intervals containing the original tank lifetimes are used to compare actual survival rates with those projected by the model. From Appendix B.1, of 66 tanks in this group, five fail in [5,10], forty nine fail in [10,16], five fail in [18,24], and their are seven tanks that survive beyond twenty-five years. Figure 9 graphs the associated actual and estimated number of tank coatings that survive through the represented intervals:

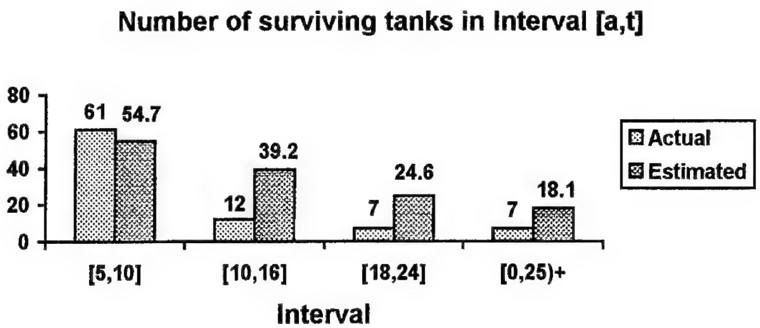


Figure 9. Comparison of Actual vs. Estimated surviving tank coatings for the JP-5 tank group.

Figure 9 reveals that the model grossly overestimates the number of surviving JP-5 tank coatings beyond the first interval [5,10]. Only seven tanks of sixty six actually survive beyond the twenty fourth year, while the fitted model shows a sustained overestimation at the sixteenth, twenty-fourth and twenty-fifth years. This is likely a result of the small shape factor for this model ($\hat{\kappa} = 1.70$) compared to the fuel oil model ($\hat{\kappa} = 6.91$). Comparing the summary interval charts, the JP-5 group has some early failures, while those in the fuel oil group are more clustered about the mean life. Early life failures are captured in the Weibull distribution with a small shape factor. In contrast, the fuel oil model has a large shape factor to generate a steeper failure rate about the characteristic life. The lower shape factor results in a failure rate that is too small in the vicinity of the characteristic life and overestimates the survival rate. This is also depicted in the failure rate curves for the fuel oil and JP-5 groups in Appendix D. The failure rate curve for the JP-5 group is much more gradual than the very steep fuel oil curve. For this group the estimate of the number of tanks to survive beyond twenty-five years is 18.1 which over estimates the actual number of survivors (7).

3. CV-67 Damage and List Control Voids (56 voids in group)

This group also has tanks with multiple lifetimes. From Appendix B.1, of 56 tanks in this group, first life coating failures are; thirty two failures at [10,16], and seven failures at [18,24]. Seventeen voids survive beyond twenty-five years. Figure 10 graphs the

associated actual and estimated number of tank coatings that survive through the represented intervals:

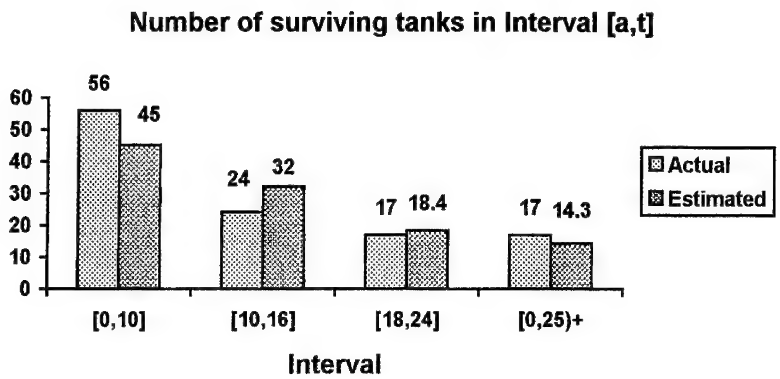


Figure 10. Comparison of Actual vs. Estimated surviving tank coatings for DC\LC voids.

The estimated shape factor for the DC/LC void group is $\hat{\kappa}$=2.00. Figure 10 reveals a similar situation as discussed for the JP-5 tank group but the problem is not nearly as severe. The shape factor is a little higher than the JP-5 group and there are no early failures. The model initially underestimates the survival probability and then like the JP-5 group overestimates the estimated number of surviving tanks at the [10,16] interval. For this group the estimate of the number of voids to survive beyond twenty-five years is 14.1 which slightly under estimates the actual number of survivors (17). This model is generally reflective of the DC/LC lifetime data.

D. MODEL APPLICATION

A hypothetical repair scenario is examined in this section to illustrate how the survival functions can be employed in the repair planning process. The CV-67 fuel oil tank group is selected as the repair group candidate. The status of this group has the most certainty and the survival function model reasonably reflects historical failure data.

For the purposes of this scenario it is assumed that the three tanks with coatings that survive beyond twenty five years will fail in the interval [1994,2000]. Thus, at the

year 2000 DSRA, planning personnel will be faced with the issue of scheduling or further deferring tank overhauls for the fuel oil group. There are several options to be considered in conjunction with the time and budget constraints of the availability:

Option 1: Do nothing. Defer repairs to a later availability in favor of higher priority maintenance.

Option 2: Commit resources to repair a fraction of the fuel oil tanks at the year 2000 DSRA and continue further overhauls at later docking availabilities (2002 COH, and beyond).

With either option there are several issues that also require attention:

Issue 1: 100% of fuel oil tanks are expected to have coating failures by the 2000 DSRA.

Issue 2: The 2000 DSRA is a short docking period (10/99-2/00), and may not allow for tank overhaul repairs.

Issue 3: The other groups also have tank failures that may have higher priority within the tank and void system, particularly the JP-5 tank group.

With these issues and options in mind an example repair schedule is outlined as follows:

- Overhaul the sixteen fuel oil service (FOS) tanks at 2000 DSRA. The FOS tanks having the highest priority within the fuel oil group.
- Overhaul approximately one third (38) of the remaining failed tanks at the 2002 COH . This number is chosen arbitrarily, but is reasonable on the premise that it is very unlikely that all of the fuel oil tanks would be overhauled by the year 2000 COH. This still leaves an estimated seventy-five tanks in a failed state beyond the year 2002 COH.

The methods developed in the previous sections may now be used to evaluate this policy. In particular:

- For the sixteen FOS tanks overhauled at year 2000, $N(8) = (16)(1.00) = 16$, therefore all repaired tanks are expected to survive to EOS.

- Likewise, for the thirty eight tanks overhauled at year 2002, $N(6) = (38)(1.00) = 38$ tanks expected to survive to EOS.

With these projections, planners can consider repair choices during the remainder of ship's life. As the ship gets nearer to decommissioning, the decision to overhaul a tank has a higher impact on the utilization of resources. For instance, many of the fuel oil tanks have remained in service with documented coating failures dating back to 1987. The main purpose of the paint coating is to provide corrosion protection of the metal surface. Since the fuel oil is a petroleum product itself, it is a corrosion inhibitor. Operational policy with the tanks and voids can be changed to reflect material status. For example, in those tanks with documented paint coating failures, minimize instances of seawater incursion (ballast). Paint coating failure does not imply structural failure but is certainly a precursor. Thus the rate of deterioration inside the fuel oil tanks with failed coatings may be slow enough to allow extended deferral in favor of higher priority tanks. Consideration of these options may allow for repairing a more critical group such as the JP-5 tanks.

The predictive methods demonstrated in this section allow a more systematic approach to planning and scheduling repair by giving the maintenance planners more insight into the status of the tank and void system. This is a vast improvement over current methods that incorporate little learning to enhance the process as the ships age. With the history files in place, the survival functions can be continuously updated as new data is received. Modeling assumptions can then be assessed and revised to capture the characteristics of the coating failures. The reality of a CBMP can be effectively augmented to allocate resources and provide decision makers with a forecasting capability. Finally, options and scenarios can be assessed using the models to derive lifecycle costs which provide the basis for procuring funding.

VI. CONCLUSIONS AND RECOMMENDATIONS

This thesis has provided significant contributions to the progression of study examining the tank and void repair process. The lessons learned in this study have led to recommendations to PERA(CV) that advance the progress in gathering tank and void repair data. Further, a follow on study suggested by this thesis has been endorsed and is currently in progress at the Navy Postgraduate School. Ultimately, the goal in the systematic progression of these studies is to give guidance to decision makers in determining maintenance strategies for the tanks and voids.

A. CONCLUSIONS

Comprehensive repair history files for the tanks and voids on USS John F. Kennedy (CV 67) and USS Enterprise (CVN 65) were developed which comprise all maintenance availabilities beyond 1978. These data files are the most complete record of tank and void repair history known to exist. Building this type of database has proved very difficult because the documentation is so dispersed across the maintenance history of the ships. The methods used to locate the repair data and the assumptions required to specify coating failures have been detailed to provide a template for building similar databases for other ships.

The analysis of the data in the repair history files gives important implications to modeling tank and void coating failures. The aircraft carriers in this study are of different class type and have different repair histories. The estimated survival functions among the tank and void groups were more similar within a ship, than those between ships because the coating failures are clustered about the repair periods particular to each ship. This indicates that to minimize the influence of differing repair histories, comparisons should be made between ships on similar repair schedules. Alternatively, the comparisons show that the use and maintenance of the tanks and voids on each ship may result in unique failure patterns, particularly in ships of different class type.

Since all Nimitz class carriers will transition to the Incremental Maintenance Plan (IMP), they will be on similar repair schedules. The cross-ship comparisons of failure histories for this class may provide productive fleet wide decision criteria in tank and void repair and planning. For example, if tanks of the same functional group have similar failure patterns, regular inspection and repair schemes can be developed for the entire class and resources budgeted accordingly. This would be a major step in reducing undesired growth work and unnecessary inspections.

The techniques used to develop the survival functions in this thesis provide an initial step toward the development of true predictive models. Although it was realized that the inability to include pre-1979 repairs would limit the accuracy of the models, a valuable demonstration in the predictive capabilities of these tools was demonstrated. Record keeping and tracking of tank and void status is a focal issue in the PERA organization. Tank and void entry for any reason has been designated as an opportunity to conduct an inspection and gather data. PERA's goal is 100% recording of tank and void entries and the resulting inspections into the TVDB. These efforts will reduce the length of the censuring intervals and thereby reduce the uncertainty of when coating failure occurs. As new data becomes available the models can be updated and the modeling assumptions assessed. The overall effect will be a higher resolution in the fitted models, providing better input to the maintenance planners.

B. RECOMMENDATIONS

The opportunity to examine the potential of the reliability studies conducted thus far towards developing class-wide maintenance planning strategy for the tanks and voids lies with the Nimitz class aircraft carriers. Repair history files are currently being developed for the Nimitz class JP-5 tanks with a similar analysis of the tank coatings using the methods detailed in this study. This follow-on study will encompass those Nimitz carriers that have undergone extensive docking availabilities (CVN-68, CVN-69, CVN-70). These carriers have been in service long enough to have accumulated sufficient

inspection and repair history to support a study of the tank coatings. The JP-5 group was selected because it is the most critical tank group and accounts for the vast majority of the tank and void repairs conducted thus far on this class. In addition, the newer Nimitz carriers (CVN-71, CVN-72, CVN-73) tank and void inspection histories recorded in the TVDB will be utilized to asses early life coating failures.

It is not anticipated that the limitations discussed in Chapter III will be a factor in this follow on study. Since the Nimitz class aircraft carriers are much younger than CVN-65 and CV-67 they have been through fewer docking availability periods, and therefore have fewer recorded coating failures and tank overhauls. Additionally, the data on the Nimitz class is more recent, has been better documented, and is more readily acquired. Resolution of the models and the estimated parameters will be of better quality because there should be significantly less ambiguity in the left censored intervals. Right censored intervals and coating age suspensions at the service age of the ship will be more valid given the age of the Nimitz class ships. Finally, because the repair data have been better managed, the censoring intervals will be tighter, allowing for a better fit to the data.

Complete data sets on the JP-5 tank coating failures and overhauls should provide not only an improved estimate of this group's survival functions but also allow for an effective cross-ship comparison analyses. Additional analyses into comparing the extent of same tank failures across ships by location may provide insight into the cluster effect and failure dependence issues raised in Chapter IV. This process of constructing history files and developing survival functions should be repeated for the other tank groups as well.

As the Nimitz carriers age and go through maintenance availabilities, every effort should be made to collect and analyze the failure data. The positive steps implemented by PERA toward a fleet-wide comprehensive database have made this possible. Existing models can be updated or revised to track and predict tank and void failures. A more complex model than the two parameter Weibull may be required to effectively represent the lifetime data. For instance, an adaptable model that allows for both an increasing and decreasing failure rate depending on lifetime may be more suitable.

Another focus of continued study should be in the area of analyzing costing data to develop per-tank estimates of depot level manday expenditures. In this way the unaccounted repairs listed in PERA records can be incorporated into the models. Cost estimation techniques that exist within the shipyard planning divisions, whether public or private, were not available for this study. Once the cost estimation relationships are known, unit cost models need to be developed for each functional group. Tracking and predicting tank failures is just one portion of the whole problem. Projecting costs is the other. Together, the survival functions and unit cost models can provide life cycle costs of the tanks and voids. Life cycle costs are undoubtedly a focus of concern with the TYCOM(s), and project higher profile within the budgetary echelon.

All efforts to provide a consolidated and comprehensive tank and void database should continue. At the writing of this thesis, there is discussion in regard to removing the TVDB from the ships because of lack of use. Removing the TVDB from the ships is not the answer to that problem. The TVDB will be more optimally used with proper training and centralization of responsibility. Effective management of the TVDB will also address the compartmentalization issue that prevents the tank and voids from being handled as a ship-wide system. Currently, cognizant "ownership" is broken down into the departments or divisions that directly operate a particular group of tanks. This causes a lack of standardization in inspection and recording. The likely result of removing the TVDB is a continuation or increase in missed inspection reports. Unrecorded entries into any tank or void have considerable negative consequences. Primarily, they generate the requirement for a scheduled inspection at some other time to determine the tank condition. These additional tank entries are generally only possible during a docking period and result in "open-ended" repair planning because the tank status is unknown. Depot level inspections of tanks and voids should be minimized due to the contracted cost. Depot level resources are better allocated for the purposes of repair based on previous documented inspections. These inspections should be conducted by shipboard personnel as much as possible, within the limitations that personnel manning allows.

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APPENDIX A.1. PERA MANDAY EXPENDITURE SUMMARY

	A	B	C	D	E	F	G	H
2	Hull	ESWBS	Brief	Avail Type	Activity	Fiscal Year	Auth	Expended
3	CV67	12312	JP-5 TANKS	SRA	NNSY	70	0	53
4	CV67	12310	TANK COORDINATION	SRA	NNSY	71	0	139
5	CV67	12312	JP-5 TANKS	SRA	NNSY	73	0	56
6	CV67	12311	FUEL OIL TANKS	COH	NNSY	74	0	742
7	CV67	12312	JP-5 TANKS	COH	NNSY	74	5663	2817
8	CV67	12322	VOIDS AND COFFERDAMS	COH	NNSY	74	1048	809
9	CV67	12310	TANK COORDINATION	SRA	NNSY	76	43	19
10	CV67	12322	VOIDS AND COFFERDAMS	SRA	NNSY	76	0	18
11	CV67	12311	FUEL OIL TANKS	SRA	NNSY	77	0	327
12	CV67	12312	JP-5 TANKS	COH	NNSY	79	2021	2183
13	CV67	12322	VOIDS AND COFFERDAMS	COH	NNSY	79	6500	10858
14	CV67	12311	FUEL OIL TANKS	SRA	NNSY	81	0	55
15	CV67	12312	JP-5 TANKS	SRA	NNSY	81	0	49
16	CV67	12322	VOIDS AND COFFERDAMS	SRA	NNSY	81	0	186
17	CV67	12311	FUEL OIL TANKS	SRA	NNSY	83	0	114
18	CV67	12312	JP-5 TANKS	SRA	NNSY	83	0	1
19	CV67	12322	VOIDS AND COFFERDAMS	SRA	NNSY	83	0	57
20	CV67	12311	FUEL OIL TANKS	COH	NNSY	85	4508	2052
21	CV67	12312	JP-5 TANKS	COH	NNSY	85	11639	7733
22	CV67	12322	VOIDS AND COFFERDAMS	COH	NNSY	85	2673	4726
23	CV67	12311	FUEL OIL TANKS	SRA	NNSY	87	3895	409
24	CV67	12322	VOIDS AND COFFERDAMS	SRA	NNSY	87	9	10
25	CV67	12311	FUEL OIL TANKS	SRA	NNSY	89	90	287
26	CV67	12312	JP-5 TANKS	SRA	NNSY	89	33	19
27	CV67	12322	VOIDS AND COFFERDAMS	SRA	NNSY	89	0	38
28	CV67	12310	TANK COORDINATION	SRA	NNSY	91	235	232
29	CV67	12311	FUEL OIL TANKS	SRA	NNSY	91	38	278
30	CV67	12310	TANK COORDINATION	COH	PNSY	93	10407	4800
31	CV67	12311	FUEL OIL TANKS	COH	PNSY	93	4192	5000
32	CV67	12312	JP-5 TANKS	COH	PNSY	93	7560	500
33	CV67	12315	LUBE OIL TANKS	COH	PNSY	93	21	21
34	CV67	12322	VOIDS AND COFFERDAMS	COH	PNSY	93	1469	3500
35								
36	CVN65	12312	JP-5 TANKS	SRA	NNSY	70	0	5085
37	CVN65	12311	FUEL OIL TANKS	SRA	HTPT	72	0	767
38	CVN65	12312	JP-5 TANKS	SRA	PSNS	74	0	2363
39	CVN65	12322	VOIDS AND COFFERDAMS	SRA	PSNS	74	0	471
40	CVN65	12312	JP-5 TANKS	SRA	SSSF	75	0	2574
41	CVN65	12322	VOIDS AND COFFERDAMS	SRA	SSSF	75	0	814
42	CVN65	12311	FUEL OIL TANKS	COH	PSNS	79	10920	10856
43	CVN65	12322	VOIDS AND COFFERDAMS	COH	PSNS	79	1678	2776
44	CVN65	12311	FUEL OIL TANKS	SRA	SSSF	83	0	156
45	CVN65	12312	JP-5 TANKS	SRA	SSSF	83	0	679
46	CVN65	12322	VOIDS AND COFFERDAMS	SRA	SSSF	83	0	2
47	CVN65	12312	JP-5 TANKS	SRA	SSSF	85	174	0
48	CVN65	12322	VOIDS AND COFFERDAMS	SRA	SSSF	85	0	2446
49	CVN65	12311	FUEL OIL TANKS	DSRA	SSSF	87	73	0
50	CVN65	12312	JP-5 TANKS	DSRA	SSSF	87	8570	1939
51	CVN65	12316	BALLAST TANKS	DSRA	SSSF	87	163	0
52	CVN65	12322	VOIDS AND COFFERDAMS	DSRA	SSSF	87	0	5215
53	CVN65	12310	TANK COORDINATION	SRA	SSSF	89	0	217
54	CVN65	12311	FUEL OIL TANKS	SRA	SSSF	89	462	87
55	CVN65	12312	JP-5 TANKS	SRA	SSSF	89	260	267
56	CVN65	12322	VOIDS AND COFFERDAMS	SRA	SSSF	89	100	170
57	CVN65	12312	JP-5 TANKS	RCOH	NNS	91	2009	1862
58	CVN65	12316	BALLAST TANKS	RCOH	NNS	91	553	934
59	CVN65	12322	VOIDS AND COFFERDAMS	RCOH	NNS	91	5653	7672
60	CVN65	12311	FUEL OIL TANKS	SRA	NNS	95	0	91
61	CVN65	12312	JP-5 TANKS	SRA	NNS	95	101	67
62	CVN65	12322	VOIDS AND COFFERDAMS	SRA	NNS	95	0	6

APPENDIX A.2. HISTORY FILE RESOURECES AND REFERENCES

A.2.1. CV-67 (COMMISIONED SEPTEMBER 1968)

Ship ESWBS Repair Availability Manday Summary maintained at PERA(CV) offices, Bremerton, WA, used as the baseline reference document for determining potential data sources. Manday Summary is given in Appendix A.1. Mandays expended per ESWBS were cross referenced to available documentation.

<u>Summary</u>

- <u>Notes</u>: Tank and void history prior to 1979 COH not found. ESWBS Manday Summary notes the following extensive expenditures that could not be tracked:
  - 1974 COH conducted at NNSY:
    - 742 mandays of maintenance on fuel oil tanks
    - 2817 mandays of maintenance on JP-5 tanks
    - 809 mandays of maintenance on voids and cofferdams
- 1979 COH conducted at NNSY:
  - 1979 Authorized SARP for CV-67 extracted from PERA(CV) archives, Bremerton, WA.
- 1985 COH conducted at NNSY:
  - NNSY Automated Planning System (APS) Database.
  - 1985 CV-67 COH Docking Report, Tank Preservation Data, extracted from PERA(CV) archives, Bremerton, WA.
  - Authorized Work Package Control Document for CV-67 FY 85 COH, extracted from PERA(CV) archives, Bremerton, WA.
- 1987 SRA conducted at NNSY:
  - NNSY Automated Planning System (APS) Database.
  - Tank and Void Repair Status Matrix, USS John F. Kennedy (CV 67), NAVSEADET PERA(CV), Bremerton, WA, 1988.
- 1989 SRA conducted at NNSY:

- NNSY Automated Planning System (APS) Database.

- Authorized Integrated Work Package Control Document for CV-67 FY89 SRA, extracted from PERA(CV) archives, Bremerton, WA.

- 1991 SRA conducted at NNSY:

  - NNSY Automated Planning System (APS) Database.

  - Authorized Integrated Work Package Control Document for CV-67 FY91 SRA, extracted from PERA(CV) archives, Bremerton, WA.

- 1993 - 1994 COH conducted at PNSY:

  - USS Kennedy (CV 67) Tank and Void Status and Work Report, Code 378, Philadelphia Naval Shipyard, April 7, 1995.

  - Tank and Void Inspection Database, Advanced Revelations Database Management, extracted at PERA(CV) office, Bremerton, WA.

  - Authorized Integrated Work Package Control Document for CV-67 FY93 COH, extracted from PERA(CV) archives, Bremerton, WA.

APPENDIX A.2. HISTORY FILE RESOURECES AND REFERENCES

A.2.2. CVN-65 (COMMISIONED NOVEMBER 1961)

Ship ESWBS Repair Availability Manday Summary maintained at PERA(CV) offices, Bremerton, WA, used as the baseline reference document for determining potential data sources. Manday Summary is given in Appendix A.2. Mandays expended per ESWBS were cross referenced to available documentation.

Summary

- Notes: Tank and void history prior to 1979 COH not found. ESWBS Summary begins at 1970. Extent of tank and void work conducted prior to 1970 unknown. ESWBS Manday Summary notes the following extensive expenditures that could not be tracked:
  - 1970 SRA conducted at NNSY:
    - 5085 mandays of maintenance on JP-5 tanks
    - 767 mandays of maintenance on fuel oil tanks
  - 1974 SRA conducted at PSNS:
    - 2363 mandays of maintenance on JP-5 tanks
  - 1975 SRA conducted at PSNS:
    - 2574 mandays of maintenance on JP-5 tanks
- 1979 COH conducted at PSNS:
  - 1979 SARP USS Enterprise CVN-65, Work Package Control List, extracted from PERA(CV) archives, Bremerton, WA.
- 1983 SRA conducted at SSSF:
  - 1983 SARP USS Enterprise CVN-65, Work Package Control List, extracted from PERA(CV) archives, Bremerton, WA.
- 1985 SRA conducted at SSSF:
  - Completion Work Package Control Document, USS Enterprise (CVN-65) FY 85 SRA

- Tank and Void Repair Status Matrix, USS Enterprise (CVN 65), NAVSEADET PERA(CV), Bremerton, WA., November 3, 1987.

- 1987 DSRA conducted at SSSF:

  - Departure Report, USS Enterprise (CVN-65) FY DSRA Costs, extracted from PERA(CV) archives, Bremerton, WA.

  - Authorized Work Package Control Document, USS Enterprise (CVN-65), FY 87 DSRA, extracted from PERA(CV) archives, Bremerton, WA.

  - Tank and Void Repair Status Matrix, USS Enterprise (CVN-65), NAVSEADET PERA(CV), Bremerton, WA, November 3, 1987.

- 1989 SRA conducted at SSSF:

  - Integrated Work Package Control Document, USS Enterprise (CVN-65), FY 89 SRA, extracted from PERA(CV) archives, Bremerton, WA.

- 1991-1994 RCOH conducted at NNSY:

  - Integrated Work Package Control Document, USS Enterprise (CVN-65), FY 91 RCOH, extracted from PERA(CV) archives, Bremerton, WA.

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  - CVN-65 Tank Paint Schedule (1991-1994 RCOH), NNSY

  - CVN-65 Tank Entry and Work Permits (1991-1994 RCOH), Stu Vreeland, Tank Inspector, NNSY

  - CVN-65 Tank and Void work status matrix, (1991-1994 RCOH), Stu Vreeland, Tank Inspector, NNSY

  - LT Jeffrey Wilcox, Assistant Damage Control Officer, USS Enterprise, 1992-1995.

APPENDIX A.3. CV-67 FUEL OIL TANK HISTORY FILE

	A	B	C	D	E	F	G	H	I	J	K	L	M
1							REPAIR CODE LEGEND						
2													
3	PR = PIPING REPAIRS						RL = REPAIR LEAK			ER = ELECTRICAL REPAIR			
4	INS = INSPECTION						R = REPAIR			I/R = INSPECTION & REPAIR			
5	SR = STRUCTURAL REPAIRS						WC = WHEELER CLEAN			OVHL = OVERHAUL (BLAST & PAINT)			
6	C = CLEAN												
7													
8	SWLIN	SERVICE	TANK	LAST INS DATE	COND	1979 COH	1985 COH	1987 TVMR	1989 SRA	1991 SRA	1993 COH	PAINTED	INTERVALS
9	12311	FO	67-8-123-1-F	5-Oct-94	0						C		[16,24]
10	12311	FO	67-8-123-2-F	12-Aug-94	0			30 % bad paint (84)			C		[16,24]
11	12311	FO	67-8-123-3-F	18-Aug-94	0		PR	40% bad paint (85)			C		[16,24]
12	12311	FO	67-8-123-4-F	5-Oct-94	0		PR	C, 100% corrosion (1987)			C		[10,18]
13	12311	FO	67-8-127-1-F	29-Sep-94	0		PR	40% bad paint (85)			OVHL	94	[16,24]
14	12311	FO	67-8-127-4-F	15-Oct-94	0		PR	C, 100% corrosion (1987)			C		[10,18]
15	12311	FO	67-8-131-1-F	28-Sep-94	0		PR	50% bad paint (85)			C		[10,16]
16	12311	FO	67-8-131-2-F	1-Sep-94	0		PR	C, 100% corrosion (1987)			SR		[10,18]
17	12311	FO	67-8-131-3-F	19-Aug-94	0						SR		[16,24]
18	12311	FO	67-8-162-1-F	6-Sep-94	0		INS	25% bad paint (84)			C		[16,24]
19	12311	FO	67-8-162-2-F	2-Oct-94	0						C		[16,24]
20	12311	FO	67-8-162-3-F	13-Sep-94	0		PR				C		[16,24]
21	12311	FO	67-8-162-4-F	15-Jul-94	0						C		[16,24]
22	12311	FO	67-8-162-5-F	13-Sep-94	0						C		[16,24]
23	12311	FO	67-8-162-6-F	26-May-94	0						C		[16,24]
24	12311	FO	67-8-172-1-F	3-May-94	0		RL	10% bad paint (84)			C		[16,24]
25	12311	FO	67-8-172-2-F	17-Jun-94	0			10% bad paint (84)			C		[16,24]
26	12311	FO	67-8-172-3-F	22-Jun-94	0				C		C		[16,24]
27	12311	FO	67-8-172-4-F	15-Jun-94	0		R		C		C		[16,24]
28	12311	FO	67-8-172-5-F	13-May-94	0						C		[16,24]
29	12311	FO	67-8-172-6-F	16-Jun-94	0		R				C		[16,24]
30	12311	FO	67-8-177-1-F	2-Oct-94	0			10% bad paint (84)		I/R	C		[16,24]
31	12311	FO	67-8-177-2-F	27-Jul-94	0			10% bad paint (84)		I/R	C		[16,24]
32	12311	FO	67-8-177-3-F	17-Jul-94	0						C		[16,24]
33	12311	FO	67-8-177-4-F	16-Jun-94	0						C		[16,24]
34	12311	FO	67-8-180-1-F	1-Jul-94	0						C		[16,24]
35	12311	FO	67-8-180-2-F	22-Apr-94	0						C		[16,24]
36	12311	FO	67-8-185-1-F	25-Oct-94	0				I/R	I/R	WC		[16,24]
37	12311	FO	67-8-185-2-F	5-Aug-94	0		R		I/R	PR	SR		[16,24]
38	12311	FO	67-8-185-3-F	4-Jan-94	1			50% bad paint (85)	I/R	INSP	C		[10,16]
39	12311	FO	67-8-185-4-F	18-Aug-94	0		R	40% bad paint (85)	C		C		[16,24]
40	12311	FO	67-8-195-1-F	21-Oct-94	0						WC		[16,24]
41	12311	FO	67-8-195-2-F	27-Jul-94	0						C		[16,24]
42	12311	FO	67-8-205-1-F	9-Jul-94	0						SR		[16,24]
43	12311	FO	67-8-205-2-F	9-Jul-94	0						SR		[16,24]
44	12311	FO	67-8-73-2-F	13-Jan-96	0					maj PR	C		[16,24]
45	12311	FO	67-8-78-1-F	13-Jan-96	0					maj PR	C		[16,24]
46	12311	FO	67-8-78-2-F	17-Jun-94	0		RL			maj PR	C		[16,24]
47	12311	FO	67-8-83-1-F	13-Jan-96	0		PR	40% bad paint (1984)		maj PR	WC		[16,24]
48	12311	FO	67-8-83-2-F	17-Jun-94	0		R			maj PR	C		[16,24]
49	12311	FO	67-8-88-1-F	14-Jan-96	0		INS	30% bad paint (84)		maj PR	C		[16,24]
50	12311	FO	67-8-88-2-F	15-May-94	0					maj PR	C		[16,24]
51	12311	FO	67-8-92-1-F	2-Aug-94	0			60% bad paint (1984)		maj PR	C		[10,16]
52	12311	FO	67-8-92-2-F	2-Aug-94	0			30% bad paint (84)		maj PR	C		[16,24]
53	12311	FO	67-8-97-3-F	25-Aug-94	0		PR	40% bad paint (85)		maj PR	WC		[16,24]
54	12311	FO	67-8-97-4-F	30-Sep-94	0					maj PR	WC		[16,24]
55	12311	FOB	67-7-162-3-F	15-Jul-94	0						C		[16,24]
56	12311	FOB	67-7-162-4-F	16-Jul-94	0						C		[16,24]
57	12311	FOB	67-7-167-3-F	23-Jun-94	0						C		[16,24]
58	12311	FOB	67-7-167-4-F	25-Jun-94	0						C		[16,24]
59	12311	FOB	67-7-172-3-F	26-May-94	0						WC		[16,24]
60	12311	FOB	67-7-172-4-F	26-May-94	0						WC		[16,24]
61	12311	FOB	67-8-105-6-F	18-Jul-94	0				INSP		C		[18,24]
62	12311	FOB	67-8-105-7-F	14-Jun-94	0			40% bad paint (85)	I/R		C		[16,24]
63	12311	FOB	67-8-110-7-F	17-Jun-94	0		PR	50% bad paint (85)	REPAIR		C		[10,16]
64	12311	FOB	67-8-110-8-F	23-Aug-94	0						C		[16,24]
65	12311	FOB	67-8-115-7-F	24-Jun-94	0						C		[16,24]
66	12311	FOB	67-8-115-8-F	24-Jun-94	0				I/R		C		[16,24]
67	12311	FOB	67-8-136-8-F	27-Jun-94	0			C, 8% bad paint (87)			C		[18,24]
68	12311	FOB	67-8-136-9-F	23-Jun-94	0		PR	C, 10% corrosion (87)			C		[18,24]
69	12311	FOB	67-8-140-5-F	17-Jul-94	0			C, 10% bad paint (87)		INSP	C		[18,24]
70	12311	FOB	67-8-140-6-F	12-Nov-94	0			C, 15% bad paint (87)	SR		C		[18,24]
71	12311	FOB	67-8-149-10-F	6-Jul-94	0			0% bad paint\corrosoin (87)			C		[18,24]
72	12311	FOB	67-8-149-7-F	6-Sep-94	0			15% corrosion (87)		INSP	C		[18,24]

APPENDIX A.3. CV-67 FUEL OIL TANK HISTORY FILE

	A	B	C	D	E	F	G	H	I	J	K	L	M
73	SWLIN	SERVICE	TANK	LAST INS DATE	COND	1979 COH	1985 COH	1987 TVMR	1989 SRA	1991 SRA	1993 COH	PAINTED	INTERVALS
74	12311	FOB	67-8-153-5-F	29-Jul-94	0				I/R	INSP	C		[16,24]
75	12311	FOB	67-8-153-6-F	19-Jul-94	0			55% corrosion (87)			C		[10,18]
76	12311	FOB	67-8-157-7-F	11-Aug-94	0			20% corrosion (87)	I/R	INSP	C		[16,24]
77	12311	FOB	67-8-157-8-F	16-Aug-94	0			7% corrosion (87)			C		[16,24]
78	12311	FOB	67-8-162-7-F	26-May-94	0				INSP	INSP	C		[16,24]
79	12311	FOB	67-8-162-8-F	17-Jul-94	0				C		C		[16,24]
80	12311	FOB	67-8-177-7-F	3-May-94	0						C		[16,24]
81	12311	FOB	67-8-177-8-F	3-May-94	0		R	30% bad paint (85)			C		[16,24]
82	12311	FOB	67-8-181-3-F	5-May-94	0						C		[16,24]
83	12311	FOB	67-8-181-4-F	10-May-94	0		R	40% bad paint (85)			C		[16,24]
84	12311	FOB	67-8-181-5-F	4-May-94	0						C		[16,24]
85	12311	FOB	67-8-181-6-F	10-May-94	0		R	50% bad paint			C		[10,16]
86	12311	FOB	67-8-195-3-F	28-Jun-94	0						C		[16,24]
87	12311	FOB	67-8-205-3-F	19-Jul-94	0						SR		[16,24]
88	12311	FOB	67-8-73-1-F	14-Mar-93	0					maj PR	C		[16,24]
89	12311	FOB	67-8-83-3-F	22-Apr-94	0		ER	60% bad paint (1984)		maj PR	C		[10,16]
90	12311	FOB	67-8-83-4-F	26-Apr-94	0					maj PR	C		[16,24]
91	12311	FOB	67-8-92-3-F	25-Apr-94	0					maj PR	C		[16,24]
92	12311	FOB	67-8-92-4-F	3-Oct-93	1					maj PR	C		[0,24)+
93	12311	FOB	67-8-97-5-F	18-Jun-94	0					maj PR	C		[16,24]
94	12311	FOB	67-8-97-6-F	1-Jul-94	0					maj PR	C		[16,24]
95	12311	FOOB	67-7-162-7-F	15-Jun-94	0				I/R	INSP	C		[16,24]
96	12311	FOOB	67-7-162-8-F	15-Jun-94	0						C		[16,24]
97	12311	FOOB	67-7-167-5-F	25-Jul-94	0				C		C		[16,24]
98	12311	FOOB	67-7-167-6-F	25-Jul-94	0				C		C		[16,24]
99	12311	FOOB	67-8-101-5-F	3-Jan-96	0			6% bad paint (84)			C		[16,24]
100	12311	FOOB	67-8-101-6-F	11-Jan-94	1								[0,24)+
101	12311	FOOB	67-8-119-7-F	5-Jul-94	0		PR	50% bad paint (85)	C		C		[10,16]
102	12311	FOOB	67-8-119-8-F	2-Aug-94	0					PR	C		[16,24]
103	12311	FOOB	67-8-123-5-F	5-Oct-94	0					INSP	C		[16,24]
104	12311	FOOB	67-8-123-6-F	20-Jul-94	0			5% bad paint/corrosion (1987)			C		[18,24]
105	12311	FOOB	67-8-131-5-F		0								[16,24]
106	12311	FOOB	67-8-131-6-F	31-Aug-94	0			100% corrosion (1987)			PR		[10,18]
107	12311	FOOB	67-8-145-7-F	23-Aug-94	0		PR	C, 20% corrosion (87)			C		[18,24]
108	12311	FOOB	67-8-145-8-F	13-Jul-94	0			5% bad paint/corrosion (1987)	I/R		C		[18,24]
109	12311	FOOB	67-8-167-1-F	28-Jun-94	0				C		C		[16,24]
110	12311	FOOB	67-8-167-2-F	30-Jul-94	0						PR		[16,24]
111	12311	FOOB	67-8-172-7-F	18-Jun-94	0						C		[16,24]
112	12311	FOOB	67-8-172-8-F	18-Jan-94	0						PR		[16,24]
113	12311	FOOB	67-8-177-5-F	19-Sep-94	0				C		C		[16,24]
114	12311	FOOB	67-8-177-6-F	25-Sep-94	0		R	50% bad paint (84)	C		C		[10,16]
115	12311	FOOB	67-8-181-1-F	19-Sep-94	0				C		C		[16,24]
116	12311	FOOB	67-8-181-2-F	22-Jul-94	1				C		C		[0,24)+
117	12311	FOOB	67-8-195-4-F	22-Oct-93	0						C		[16,24]
118	12311	FOOB	67-8-200-1-F	22-Oct-93	0						OVHL	25-Jul-94	[16,24]
119	12311	FOOB	67-8-78-3-F	21-Jun-94	0				C	maj PR	C		[16,24]
120	12311	FOOB	67-8-78-4-F	24-Jun-94	0				C	maj PR	C		[16,24]
121	12311	FOOB	67-8-88-3-F	3-Oct-93	0		PR	30% bad paint (84)	C	maj PR	WC		[16,24]
122	12311	FOOB	67-8-88-4-F	9-May-94	0				C	maj PR	C		[16,24]
123	12311	FOS	67-8-105-8-F	30-Aug-94	0		PR/ER	20% bad paint (84)	I/R		PR		[18,24]
124	12311	FOS	67-8-105-9-F	20-Jun-94	0		RL	60% bad paint (85)	I/R		C		[10,16]
125	12311	FOS	67-8-110-10-F	20-Jun-94	0		PR/ER	50% bad paint (84)			C		[10,16]
126	12311	FOS	67-8-110-9-F	20-Jun-94	0		PR	95% bad paint (85)			C		[10,16]
127	12311	FOS	67-8-136-10-F	23-Jun-94	0		PR	C, 10% corrosion (87)			C		[18,24]
128	12311	FOS	67-8-136-11-F	28-Jun-94	0			C, 5% bad paint (87)			C		[18,24]
129	12311	FOS	67-8-144-1-F	13-Sep-94	0			C, 25% corrosion (87)			C		[18,24]
130	12311	FOS	67-8-144-2-F	30-Jun-94	0			100% corrosion (87)]	I/R		C		[10,16]
131	12311	FOS	67-8-149-12-F	1-Jul-94	0		PR	3% bad paint\corrosion (87)			C		[18,24]
132	12311	FOS	67-8-149-9-F	30-Jun-94	0		PR	C, 8% corrosion (87)		INSP	C		[18,24]
133	12311	FOS	67-8-157-10-F	11-Aug-94	0		ER	C, 5% corrosoion (87)			C		[18,24]
134	12311	FOS	67-8-157-9-F	24-Aug-94	0		PR	C	I/R	INSP	C		[16,24]
135	12311	FOS	67-8-97-7-F	4-Jan-96	0		PR	50% bad paint (84)		maj PR	C		[10,16]
136	12311	FOS	67-8-97-8-F	10-Jun-94	0		PR	80% bad paint (84)		maj PR	C		[10,16]
137	12311	FOS	67-8-118-1-F	16-Jun-94	0		PR/RL	80% bad paint (85)		I/R	C		[10,16]
138	12311	FOS	67-8118-2-F	18-Jun-94	0		PR/ER	80% bad paint (84)			C		[10,16]

APPENDIX A.4. CV-67 JP-5 TANK HISTORY FILE

	A	B	C	D	E	F	G	H	I	J	K
1						REPAIR CODE LEGEND					
2											
3	OVHL = OVERHAUL (BLAST & PAINT)								TLI = TANK LEVEL INDICATOR REPAIR		
4	WC = WHEELER CLEAN								C= CLEAN		
5											
6	SWLIN	SERVICE	TANK	LAST INS DATE	COND	1979 COH	1985 COH	1987 TVMR	1993 COH	PAINTED	INTERVALS
7	12312	JB	67-7-190-1-J	17-Aug-94	1		OVHL		C		[10,16] , [0,9]+
8	12312	JB	67-7-190-2-J	19-May-94	1		OVHL	5% bad paint (84)	C		[10,16] , [0,9]+
9	12312	JB	67-8-12-0-J	26-Oct-93	1			10% bad paint (84)	TLI		[0,25)+
10	12312	JB	67-8-16-0-J	23-Apr-94	1		OVHL	15% bad paint (84)	TLI		[10,16] , [0,9]+
11	12312	JB	67-8-185-10-J	17-May-94	1		OVHL	20% bad paint (84)	C	1-Jan-85	[10,16] , [0,9]+
12	12312	JB	67-8-185-5-J	24-Aug-94					C		[0,25)+
13	12312	JB	67-8-185-6-J	3-Aug-94					C		[0,25)+
14	12312	JB	67-8-185-7-J	19-Aug-94	1		OVHL	10% bad paint (84)	C		[10,16] , [0,9]+
15	12312	JB	67-8-185-8-J	21-Jun-94			OVHL	10% bad paint (84)	C		[10,16] , [0,9]+
16	12312	JB	67-8-185-9-J	19-Aug-94	1-			1% bad paint (84)	C		[0,25)+
17	12312	JB	67-8-19-0-J	11-May-94	1-	OVHL	C	2% bad paint (84)	C		[5,10] , [0,15)+
18	12312	JB	67-8-195-7-J	18-Jul-94	1				C		[0,25)+
19	12312	JB	67-8-195-8-J	23-Nov-93	0		OVHL	12% bad paint (84)	OVHL	94	[10,16] , [2,8]
20	12312	JB	67-8-23-0-J	25-Mar-94	1		OVHL	0% bad paint (84)	C		[10,16] , [0,9]+
21	12312	JB	67-8-28-0-J	11-Apr-94	1	OVHL		0% bad paint (80)	C		[5,10] , [0,15)+
22	12312	JB	67-8-28-1-J	7-May-94	1		OVHL	0% bad paint (85)	TLI		[10,16] , [0,9]+
23	12312	JB	67-8-28-2-J	28-Apr-94	1		OVHL	1% bad paint (85)	OVHL	94	[10,16] , [2,8]
24	12312	JB	67-8-33-0-J	9-Jun-94		OVHL			C		[5,10] , [0,15)+
25	12312	JB	67-8-33-1-J	28-Mar-93	1		OVHL		C		[10,16] , [0,9]+
26	12312	JB	67-8-33-2-J	30-Mar-94	1		OVHL		C		[10,16] , [0,9]+
27	12312	JB	67-8-33-3-J	7-May-94	1-	OVHL		4% bad paint/corrosion (88)	C		[5,10] , [0,15)+
28	12312	JB	67-8-33-4-J	6-Apr-94	1		OVHL	0% bad paint	C		[10,16] , [0,9]+
29	12312	JB	67-8-43-1-J	30-Apr-94	1		OVHL	5% bad paint (84)	C		[10,16] , [0,9]+
30	12312	JB	67-8-48-1-J	20-May-94	1		INS		OVHL	94	[18,24]
31	12312	JB	67-8-48-2-J	1-Jun-94	1		OVHL	8% bad paint (84)	C	1-Jan-85	[10,16] , [0,9]+
32	12312	JB	67-8-53-3-J	19-Mar-94	1-	INSP	OVHL	1% bad paint (84)		1-Jan-85	[10,16] , [0,9]+
33	12312	JB	67-8-53-4-J	11-May-94	1		OVHL	0% bad paint (84)	TLI		[10,16] , [0,9]+
34	12312	JB	67-8-53-6-J	1-Jul-94	1		OVHL	0% bad paint (84)	WC		[10,16] , [0,9]+
35	12312	JB	67-8-58-3-J	28-Jun-94	1		OVHL	15% bad paint (84)	C		[10,16] , [0,9]+
36	12312	JB	67-8-63-1-J	17-Mar-94	1		OVHL	10% bad paint (84)	C		[10,16] , [0,9]+
37	12312	JB	67-8-63-4-J	29-Mar-94	0		OVHL	3% bad paint (84)	C	1-Jan-85	[10,16] , [0,9]+
38	12312	JB	67-8-73-3-J	24-May-95			OVHL	8% bad paint (84)	C		[10,16] , [0,9]+
39	12312	JB	67-8-73-4-J	4-May-94	1		OVHL	7% bad paint (84)	C	1-Mar-94	[10,16] , [0,9]+
40	12312	JB	67-8-9-0-J	21-Jun-94	1-			0% bad paint	C		[0,25)+
41	12312	JOB	67-8-190-1-J	29-Aug-94	1		OVHL	15% bad paint (84)	OVHL	94	[10,16] , [2,8]
42	12312	JOB	67-8-190-2-J	5-May-94	1				C		[0,25)+
43	12312	JOB	67-8-190-3-J	20-Jun-94	1		OVHL	25% bad paint (84)	OVHL	94	[10,16] , [2,8]
44	12312	JOB	67-8-190-4-J	31-Jul-94	1			1% bad paint (84)	OVHL	94	[18,24]
45	12312	JOB	67-8-200-5-J	14-Dec-93	0	OVHL	PR	1% bad paint (84)	OVHL	94	[5,10] , [8,14]
46	12312	JOB	67-8-200-6-J	31-Jul-94	1		OVHL	15% bad paint (84)	OVHL	94	[10,16] , [2,8]
47	12312	JOB	67-8-43-2-J	10-Nov-93	1		OVHL	0% bad paint (84)	TLI		[10,16] , [0,9]+
48	12312	JOB	67-8-48-3-J	24-Jun-94	1		INS		OVHL	94	[18,24]
49	12312	JOB	67-8-48-4-J	15-Jun-94	1		OVHL	0% bad paint (84)	TLI		[10,16] , [0,9]+
50	12312	JOB	67-8-53-1-J	5-Sep-94	1		INS		OVHL	94	[18,24]
51	12312	JOB	67-8-58-2-J	2-Nov-93	1		OVHL	4% bad paint (04)	TLI		[10,16] , [0,9]+
52	12312	JOB	67-8-68-2-J	22-Jul-94	1		OVHL	4% bad paint (84)	TLI		[10,16] , [0,9]+
53	12312	JOB	67-8-68-3-J	26-Oct-93	1		OVHL	10% bad paint (84)	TLI		[10,16] , [0,9]+
54	12312	JP	67-8-38-0-J	16-Sep-93	0		INS		OVHL	94	[18,24]
55	12312	JP	67-8-43-0-J	17-Mar-94			OVHL	5% bad paint (84)	C		[10,16] , [0,9]+
56	12312	JP	67-8-48-0-J	11-Jul-94	1-	OVHL		1% bad paint (84)	C	1-Jan-85	[10,16] , [0,9]+
57	12312	JP	67-8-53-0-J	10-Nov-94			OVHL	10% bad paint (84)	WC		[10,16] , [0,9]+
58	12312	JP	67-8-53-2-J	5-Oct-94	1		OVHL	15% bad paint (84)	OVHL	5-Oct-94	[10,16] , [2,8]
59	12312	JP	67-8-58-0-J	22-Jul-94	1		OVHL	20% bad paint (84)	C		[10,16] , [0,9]+
60	12312	JP	67-8-58-1-J	14-Mar-94			OVHL	50% bad paint (84)	C		[10,16] , [0,9]+
61	12312	JP	67-8-63-2-J	25-Jul-94	1		OVHL	30% bad paint (84)	C		[10,16] , [0,9]+
62	12312	JP	67-8-68-0-J	21-Jul-94	1-		OVHL	10% bad paint (84)	C	1-Jan-85	[10,16] , [0,9]+
63	12312	JP	67-8-68-1-J	17-Apr-94			OVHL	0% bad paint (84)	WC		[10,16] , [0,9]+
64	12312	JP SERV	67-8-195-5-J	21-Jun-94	1		OVHL	5% bad paint (84)	C		[10,16] , [0,9]+
65	12312	JP SERV	67-8-195-6-J	26-Jul-94	1		OVHL	5% bad paint (84)	OVHL	94	[10,16] , [2,8]
66	12312	JP SERV	67-8-200-3-J	19-Jun-94	1		OVHL	5% bad paint (84)	TLI		[10,16] , [0,9]+
67	12312	JP SERV	67-8-200-4-J	19-Jun-94	1		OVHL	5% bad paint (84)	OVHL	94	[10,16] , [2,8]
68	12312	JP SERV	67-8-38-1-J	15-Nov-93	1		OVHL	10% bad paint (84)	TLI		[10,16] , [0,9]+
69	12312	JP SERV	67-8-38-2-J	7-Dec-93	1		OVHL	10% bad paint (84)	TLI		[10,16] , [0,9]+
70	12312	JP SERV	67-8-43-3-J	12-Jul-94	1		OVHL	6% bad paint (84)	TLI		[10,16] , [0,9]+
71	12312	JP SERV	67-8-43-4-J	10-Nov-93	1		OVHL	5% bad paint (84)	TLI		[10,16] , [0,9]+
72	12312	JPSMTK	67-8-210-2-J	28-Dec-93	0		OVHL	0% bad paint	OVHL	94	[10,16] , [2,8]

APPENDIX A.5. CV-67 DAMAGE & LIST CONTROL VOID HISTORY FILE

	A	B	C	D	E	F	G	H	I	J	K
2											
3		OVHL = OVERHAUL (BLAST & PAINT)				FLD = FLOOD (VALVE)			I/R = INSPECTION & REPAIR		
4		PR = PIPING REPAIR				C = CLEAN			WC = WHEELER CLEAN		
5		SR = STRUCTURAL REPAIR				INSP = INSPECTION					
6											
7	SWLIN	SERVICE	TANK	LAST INS DATE	COND	1985 COH	1987 TVMR	1991 SRA	1993 COH	PAINTED	INTERVALS
8	12321	VOID DC	67-7-123-2-V	11-Jul-94		OVHL	15% bad paint/corrosion (87)		WC		[10,16] , [0,9)+
9	12321	VOID DC	67-7-123-3-V	20-Dec-93	0	OVHL	80% bad paint (in 1984)		SR/WC		[10,16] , [0,9]
10	12321	VOID DC	67-8-101-7-V	19-Jul-94		C	3% bad paint (84)		replace fld valve		[0,25)+
11	12321	VOID DC	67-8-101-8-V	30-Aug-94		C	5% bad paint (84)		replace fld valve		[0,25)+
12	12321	VOID DC	67-8-105-11-V	3-Jun-94		C	4% bad paint (84)		replace fld valve		[0,25)+
13	12321	VOID DC	67-8-115-10-V	22-Jul-94		C/PR	1% bad paint (84)		replace fld valve		[0,25)+
14	12321	VOID DC	67-8-115-9-V	1-Jul-94		OVHL	50% bad paint (in 1984)		replace fld valve		[10,16] , [0,9)+
15	12321	VOID DC	67-8-119-10-V	10-Jun-94		OVHL	80% bad paint (in 1984)		replace fld valve		[10,16] , [0,9)+
16	12321	VOID DC	67-8-136-12-V	14-Nov-94					replace fld valve		[0,25)+
17	12321	VOID DC	67-8-136-13-V	16-Jun-94		OVHL			replace fld valve		[10,16] , [0,9)+
18	12321	VOID DC	67-8-140-7-V	8-Feb-94	0	C	6% bad paint/corrosion (87)		OVHL	94	[18,24]
19	12321	VOID DC	67-8-149-11-V	19-Jul-94		OVHL	2% bad paint/corrosion (87)		replace fld valve		[10,16] , [0,9)+
20	12321	VOID DC	67-8-149-14-V	10-Sep-94		OVHL	3% bad paint/corrosion (87)		replace fld valve		[10,16] , [0,9)+
21	12321	VOID DC	67-8-153-7-V	31-Aug-94		C	6% bad paint/corrosion (87)		replace fld valve		[0,25)+
22	12321	VOID DC	67-8-157-12-V	16-Jun-94		C	8% bad paint/corrosion (87)		replace fld valve		[0,25)+
23	12321	VOID DC	67-8-162-10-V	18-Nov-94		C			replace fld valve		[0,25)+
24	12321	VOID DC	67-8-162-9-V	15-Jun-94		C	8% bad paint (84)		replace fld valve		[0,25)+
25	12321	VOID DC	67-8-167-3-V	19-Jun-94		C	1% bad paint (84)		replace fld valve		[0,25)+
26	12321	VOID DC	67-8-167-4-V	3-Aug-94		OVHL	60% bad paint (1984)		replace fld valve		[10,16] , [0,9)+
27	12321	VOID DC	67-8-65-2-V	2-May-94		OVHL	25% bad paint (1984)		replace fld valve		[10,16] , [0,9)+
28	12321	VOID DC	67-8-65-3-V	2-Feb-94		OVHL	30% bad paint (1984)	I/R	replace fld valve		[10,16] , [0,9)+
29	12321	VOID DC	67-8-68-4-V	25-Jan-94		C/PR	40% bad paint (1985)		replace fld valve		[0,25)+
30	12321	VOID DC	67-8-68-5-V	2-Feb-94		C	30% bad paint (1985)	I/R	replace fld valve		[0,25)+
31	12321	VOID DC	67-8-73-5-V	2-Feb-94		C	30% bad paint (1984)	maj PR	replace fld valve		[0,25)+
32	12321	VOID DC	67-8-73-6-V	23-Nov-93	0	OVHL	40% bad paint (1984)	maj PR	OVHL	94	[10,16] , [0,9]
33	12321	VOID DC	67-8-78-5-V	2-Feb-94		C	15% bad paint (1984)	maj PR	replace fld valve		[0,25)+
34	12321	VOID DC	67-8-78-6-V	25-Jan-94		OVHL		maj PR	replace fld valve		[10,16] , [0,9)+
35	12321	VOID DC	67-8-83-5-V	4-Feb-94		OVHL	20% bad paint (1984)	maj PR	replace fld valve		[10,16] , [0,9)+
36	12321	VOID DC	67-8-83-6-V			OVHL	40% bad paint (1984)	maj PR	replace fld valve		[10,16] , [0,9)+
37	12321	VOID DC	67-8-88-5-V	4-Feb-94		OVHL	30% bad paint (1984)	maj PR	replace fld valve		[10,16] , [0,9)+
38	12321	VOID DC	67-8-88-6-V	20-May-94		C	25% bad paint (1984)	maj PR	replace fld valve		[0,25)+
39	12321	VOID DC	67-8-92-5-V	26-May-94		OVHL	40% bad paint (1984)	maj PR	replace fld valve		[10,16] , [0,9)+
40	12321	VOID DC	67-8-92-6-V	9-Oct-93	1	OVHL	70% bad paint (1984)	maj PR	replace fld valve		[10,16] , [0,9)+
41	12321	VOID DC	67-8-97-10-V	20-May-94		OVHL	40% bad paint (1984)	maj PR	replace fld valve		[10,16] , [0,9)+
42	12321	VOID DC	67-8-97-9-V	20-May-94		OVHL	40% bad paint (1984)	maj PR	replace fld valve		[10,16] , [0,9)+
43	12321	VOID LC	67-4-100-1-V	18-Jan-95		OVHL		maj PR	WC		[10,16] , [0,9)+
44	12321	VOID LC	67-4-115-3-V	17-Dec-94		OVHL			WC		[10,16] , [0,9)+
45	12321	VOID LC	67-4-115-6-V	18-Dec-94		OVHL		I/R	WC		[10,16] , [0,9)+
46	12321	VOID LC	67-4-123-12-V	24-Jan-95		OVHL			C		[10,16] , [0,9)+
47	12321	VOID LC	67-4-136-12-V	19-Jan-95		OVHL			PR/WC		[10,16] , [0,9)+
48	12321	VOID LC	67-4-136-7-V	24-Jan-95		OVHL			WC		[10,16] , [0,9)+
49	12321	VOID LC	67-4-149-5-V	20-Jan-95		OVHL		INSP	WC		[10,16] , [0,9)+
50	12321	VOID LC	67-4-149-8-V	17-Dec-94		OVHL			WC		[10,16] , [0,9)+
51	12321	VOID LC	67-4-162-3-V	20-Dec-94		OVHL		INSP	WC		[10,16] , [0,9)+
52	12321	VOID LC	67-4-162-4-V	15-Dec-94		C/PR			WC		[0,25)+
53	12321	VOID LC	67-4-177-4-V	5-Jan-95		C			WC		[0,25)+
54	12321	VOID OW/DC	67-8-123-7-V	7-Nov-94	0		40 % bad paint (84)		OVHL	94	[18,24]
55	12321	VOID OW/DC	67-8-123-8-V	20-Oct-94	0		40 % bad paint (84)		OVHL	94	[18,24]
56	12321	VOID OW/DC	67-8-127-5-V	28-Sep-93	0	C	50% bad paint (84)		OVHL	94	[10,16] , [0,9]
57	12321	VOID OW/DC	67-8-127-8-V	20-Oct-94	0	C	50% bad paint (84)		OVHL	94	[10,16] , [0,9]
58	12321	VOID OW/DC	67-8-131-7-V	5-Oct-93	0	OVHL	INS 1987		OVHL	94	[10,16] , [0,9]
59	12321	VOID OW/DC	67-8-131-8-V	17-Oct-93	0	OVHL	INS 1987		OVHL	94	[10,16] , [0,9]
60	12321	PEAK SWB	67-7-0-0-V	10-Nov-93	0				OVHL	94	[18,24]
61	12321	PEAK SWB	67-8-0-0-V	20-Nov-93	0				OVHL	94	[18,24]
62	12321	PEAK SWB	67-8-5-0-V	10-Nov-93	0	INSP/SR			OVHL	94	[18,24]
63	12321	TRUNK	67-7-3-0-T	20-Nov-93	0				OVHL	94	[18,24]
64											

APPENDIX A.6. CVN-65 FUEL OIL TANK HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
1	These are converted to JP-5 stowage tanks									
2	SWLIN	SERV	TANK	INS date	COND	INS date	COND	PAINTED	COMMENTS	INTERVALS
3				last known		previous				
4	12311	FO	65-8-106-01-FF	27-Apr-95	1		0		NNS 1994	[21,30]
5	12311	FO	65-8-106-1-FF		1	12-Oct-91	0		NNS 1994	[21,30]
6	12311	FO	65-8-106-4-FF	27-Apr-95	1	13-Oct-91	0		NNS 1994	[21,30]
7	12311	FO	65-8-108-2-FF	27-Apr-95	1	23-Oct-91	0		NNS 1994	[21,30]
8	12311	FOB	65-8-102-10-FF	26-Apr-95	1	3-Jun-92	0		94 Vreeland's matirx	[21,30]
9	12311	FOB	65-8-102-7-FF	8-Jun-95	1	13-Aug-91	1-	1-Jan-85	87 RSM	[11,23], [0,10)+
10	12311	FOB	65-8-102-8-FF	26-Apr-95	1	3-Jun-92	0		94 Vreeland's matirx	[21,30]
11	12311	FOB	65-8-102-9-FF	8-Jun-95	1	13-Aug-91	1-	1985	87 RSM	[11,23], [0,10)+
12	12311	FOB	65-8-106-12-FF	10-Apr-95	1	14-Aug-91	0		NNS 1994	[21,30]
13	12311	FOB	65-8-106-9-FF	10-May-95	1	15-Aug-91	1	1-Jan-85	87 RSM	[11,23], [0,10)+
14	12311	FOB	65-8-111-10-FF	11-Apr-95	1	15-Aug-91	1			[0,34)+
15	12311	FOB	65-8-111-7-FF	8-Jun-95	1	13-Aug-91	1	1985	87 RSM	[11,23], [0,10)+
16	12311	FOB	65-8-111-8-FF	11-Apr-95	1	3-Jun-92				[0,34)+
17	12311	FOB	65-8-111-9-FF	9-May-95	1	13-Aug-91	1	1985	87 RSM	[11,23], [0,10)+
18	12311	FOB	65-8-138-13-FF	6-Apr-95	1	26-Jun-91	1	1986	87 RSM	[11,23], [0,10)+
19	12311	FOB	65-8-138-14-FF	28-Apr-95	1	25-Mar-91	1			[0,34)+
20	12311	FOB	65-8-143-10-FF	31-May-95	1	27-May-91	1			[0,34)+
21	12311	FOB	65-8-143-11-FF	12-Apr-95	1	15-Aug-91	1	1986	87 RSM	[11,23], [0,10)+
22	12311	FOB	65-8-143-8-FF	2-May-95	1	30-May-91	1-		94 Vreeland's matirx	[21,30]
23	12311	FOB	65-8-143-9-FF	12-Apr-95	1	15-Aug-91	1	1986	87 RSM	[11,23], [0,10)+
24	12311	FOB	65-8-148-10-FF	11-Apr-95	1	20-Aug-91	1			[0,34)+
25	12311	FOB	65-8-148-8-FF	2-May-95	1	4-Jun-92	0		94 Vreeland's matirx	[21,30]
26	12311	FOB	65-8-148-9-FF	12-Apr-95	1	19-Aug-91	1	1986	87 RSM	[11,23], [0,10)+
27	12311	FOB	65-8-152-12-FF	6-Apr-95	1	4-Jun-92				[0,34)+
28	12311	FOB	65-8-152-13-FF	5-May-95	1	2-Jun-92	1	1-Jan-86	87 RSM, TVDB	[11,23], [0,10)+
29	12311	FOB	65-8-152-14-FF	19-Apr-95	1	28-Mar-91	1			[0,34)+
30	12311	FOB	65-8-157-14-FF	20-Apr-95	1	19-Jul-92	0		NNS 1994	[21,30]
31	12311	FOB	65-8-157-9-FF	5-May-95	1	22-Oct-91	1	1-Jan-86	87 RSM	[11,23], [0,10)+
32	12311	FOB	65-8-97-10-FF	26-Apr-95	1	19-Sep-90	0		94 Vreeland's matirx	[21,30]
33	12311	FOB	65-8-97-11-FF	9-May-95	1	8-Jul-91	0	1985	87 RSM	[11,23], [0,10)+
34	12311	FOOB	65-8-106-11-FF	10-May-95	1	13-Aug-91	1	1985	87 RSM	[11,23], [0,10)+
35	12311	FOOB	65-8-106-14-FF	11-Apr-95	1	19-Jul-92	0		NNS 1994	[21,30]
36	12311	FOOB	65-8-138-15-FF	6-Apr-95	1	15-Aug-91	1	1986	87 RSM	[11,23], [0,10)+
37	12311	FOOB	65-8-138-16-FF	28-Apr-95	1	25-Mar-91	1-		94 Vreeland's matirx	[21,30]
38	12311	FOOB	65-8-149-1-FF	19-Apr-95	1	19-Aug-91	1	1986	87 RSM	[11,23], [0,10)+
39	12311	FOOB	65-8-152-11-FF	19-Apr-95	1	9-Jun-92	1	1-Jan-86	87 RSM	[11,23], [0,10)+
40	12311	FOOB	65-8-157-11-FF	5-May-95	1	22-Oct-91	1	1-Jan-86	87 RSM	[11,23], [0,10)+
41	12311	FOOB	65-8-157-12-FF	20-Apr-95	1	4-Jun-92	0		NNS 1994	[21,30]
42	12311	FOOB	65-8-97-8-FF	26-Apr-95	1	24-Oct-91	0		94 Vreeland's matirx	[21,30]
43	12311	FOOB	65-8-97-9-FF	17-May-95	1	9-Jul-91	1	1985	87 RSM	[11,23], [0,10)+
44	12311	SUMP	65-8-115-4-F			7-Aug-91	0	1979, 1994	painted NNS 1994	[11,18],[0,10]
45	12311	SUMP	65-8-92-3-F			6-Oct-91	0	1979, 1994	painted NNS 1994	[11,18],[0,10]
46	12317	COST	65-8-96-3-FF	12-Jun-95	1	1-Jun-92	0		NNS 1994	[21,30]
47	12317	COST	65-8-148-7-FF	12-Apr-95	1	18-Sep-91		1986	87 RSM	[11,23], [0,10)+
48	12317	COST	65-8-162-12-FF	95	0	9-Aug-92	1-		already selected for overhaul by SF	[21,30]

APPENDIX A.7. CVN-65 JP-5 TANK HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
1	SWLIN	SERV	TANK	INS date	COND	INS date	COND	PAINTED	COMMENTS	INTERVALS
2				last known		previous				
3	12312	COST	65-8-204-2-J	95	0	16-Sep-91	1	1982	2 failures (1982,1995) already selected by SF	[11,18], [10,13]
4	12312	COST	65-8-46-1-J			1-Jun-92	1			(0,30)+
5	12312	COST	65-8-46-2-J			30-Sep-91	1	1-Jan-89	assume ok @ 79 COH	[21,28]
6	12312	COST	65-8-57-3-J			11-Oct-91	1-	1982	>9 (1991-1982) now at 13 ***	[11,18], [0,9)+
7	12312	JB	65-5-205-5-J			92	0		per Jeff Wilcox, Nuclear qualified ADCA;	[21,30]
8	12312	JB	65-5-210-1-J			92	0		These 7th deck JB tanks are part of the	[21,30]
9	12312	JB	65-6-186-8-J			92	0		secondary shield. They were sea water	[21,30]
10	12312	JB	65-7-101-0-J			92	0		compensated prior to 1992. They were overhauled	[21,30]
11	12312	JB	65-7-101-2-J			92	0		and converted to fresh water tanks by NAVSEA08	[21,30]
12	12312	JB	65-7-106-2-J			28-May-92	0		shipalt (NR) 1990 COH.	[21,30]
13	12312	JB	65-7-114-1-J			28-May-92	0			[21,30]
14	12312	JB	65-7-115-0-J			92	0			[21,30]
15	12312	JB	65-7-115-1-J			92	0		ok @ 79 COH	[21,30]
16	12312	JB	65-7-121-1-J			92	0			[21,30]
17	12312	JB	65-7-124-0-J			92	0			[21,30]
18	12312	JB	65-7-124-1-J			92	0			[21,30]
19	12312	JB	65-7-129-1-J			92	0			[21,30]
20	12312	JB	65-7-137-2-J			92	0			[21,30]
21	12312	JB	65-7-138-0-J			92	0			[21,30]
22	12312	JB	65-7-138-4-J			92	0			[21,30]
23	12312	JB	65-7-144-2-J			2-Jun-92	0			[21,30]
24	12312	JB	65-7-147-0-J			92	0			[21,30]
25	12312	JB	65-7-147-2-J			92	0			[21,30]
26	12312	JB	65-7-151-3-J			92	0			[21,30]
27	12312	JB	65-7-152-0-J			92	0			[21,30]
28	12312	JB	65-7-152-1-J			92	0			[21,30]
29	12312	JB	65-7-159-1-J			92	0			[21,30]
30	12312	JB	65-7-162-0-J			92	0			[21,30]
31	12312	JB	65-7-162-1-J			92	0			[21,30]
32	12312	JB	65-7-215-1-J			11-Oct-91	0	1982	not part of secondary shield	[11,18].[0,10]
33	12312	JB	65-7-92-0-J			assume 92	0			[21,30]
34	12312	JB	65-7-92-4-J			assume 92	0			[21,30]
35	12312	JB	65-7-98-2-J			assume 92	0			[21,30]
36	12312	JB	65-8-162-11-J			4-Sep-92	1	1-Jan-86	ok @ 79 COH	[19,24],[0,6)+
37	12312	JB	65-8-162-14-J			10-Jun-92			already selected by SF, ok @ 79 COH	[21,30]
38	12312	JB	65-8-162-9-J			4-Sep-92	1	1-Jan-86	ok @ 79 COH	[19,24],[0,6)+
39	12312	JB	65-8-163-2-J			20-Sep-91	1-			(0,30)+
40	12312	JB	65-8-167-12-J			13-Sep-91	1-	1982		[11,18], [0,9)+
41	12312	JB	65-8-167-9-J			30-Sep-91	0	1986	ok @ 79 COH	[19,24]
42	12312	JB	65-8-171-5-J			15-Aug-91	1	1-Jan-85	ok @ 79 COH	[19,24],[0,6)+
43	12312	JB	65-8-171-6-J			10-Jun-92		1982	***	[11,18]
44	12312	JB	65-8-171-7-J			1-Jan-86	1	1986	ok @ 79 COH	[19,24],[0,6)+
45	12312	JB	65-8-171-8-J			10-Jun-92				(0,30)+
46	12312	JB	65-8-176-9-J			10-Jun-92				(0,30)+
47	12312	JB	65-8-181-3-J			11-Jun-92		1982	***	[11,18]
48	12312	JB	65-8-181-4-J			11-Jun-92				(0,30)+
49	12312	JB	65-8-181-5-J			11-Jun-92		1982	***	[11,18]
50	12312	JB	65-8-181-6-J			11-Jun-92				(0,30)+
51	12312	JB	65-8-186-7-J			23-Sep-91	1			(0,30)+
52	12312	JB	65-8-186-8-J			28-Oct-91	0		***, ok @ 79 COH	[21,30]
53	12312	JB	65-8-191-1-J			16-Sep-91	1-	1982		[11,18], [0,10)+
54	12312	JB	65-8-191-2-J			17-Sep-91	0		***, ok @ 79 COH	[21,30]
55	12312	JB	65-8-205-11-J			13-Sep-91	1			(0,30)+
56	12312	JB	65-8-210-3-J			11-Jun-92				(0,30)+
57	12312	JB	65-8-215-5-J			13-Sep-91	1-	1982		[11,18], [0,10)+
58	12312	JB	65-8-215-7-J			19-Sep-91	1	1982		[11,18], [0,10)+
59	12312	JB	65-8-22-0-J			29-May-92	1	1989	ok @ 79 COH	[21,28]
60	12312	JB	65-8-47-5-J			28-Jun-92	1-			(0,30)+
61	12312	JB	65-8-47-6-J			24-Jun-92	1	1/1/1989,1982	***	[11,18], [0,8]
62	12312	JB	65-8-52-7-J			26-Sep-91	0	1982	***	[11,18], [0,10]
63	12312	JB	65-8-52-8-J			24-Jun-92	1	1982		[11,18], [0,10)+
64	12312	JB	65-8-57-4-J			1-Oct-91	1	1-Jan-89	ok @ 79 COH	[21,28]
65	12312	JB	65-8-62-5-J			10-Jul-92	1			(0,30)+
66	12312	JB	65-8-62-6-J			1-Jan-89	1			(0,30)+
67	12312	JB	65-8-62-7-J			12-Aug-92	1			(0,30)+
68	12312	JB	65-8-62-8-J			30-Sep-91	1			(0,30)+
69	12312	JB	65-8-67-5-J			29-Jul-92	1			(0,30)+
70	12312	JB	65-8-67-6-J			29-Jul-92	1	1982		[11,18], [0,10)+
71	12312	JB	65-8-72-10-J	12-Jun-95	1-	5-Aug-92	1	1-Jan-89	two failures (1989,1995)	[21,28],[3,7]
72	12312	JB	65-8-72-5-J	5-Jun-95	1	7-Aug-92	1			(0,30)+
73	12312	JB	65-8-72-7-J	5-Jun-95	1	7-Aug-92	1			(0,30)+

APPENDIX A.7. CVN-65 JP-5 TANK HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
74	SWLIN	SERV	TANK	INS date	COND	INS date	COND	PAINTED	COMMENTS	INTERVALS
75				last known		previous				
76	12312	JB	65-8-72-8-J	7-Jun-95	1-	5-Aug-92	1	1982	two failures (1982, 1995)	[11,18], [0,13]
77	12312	JB	65-8-77-5-J	5-Jun-95	1	26-Sep-91	1-			(0,30)+
78	12312	JB	65-8-77-7-J			24-Oct-91	0		*** between COH's	[21,30]
79	12312	JB	65-8-77-8-J			18-Jun-91	0		*** between COH's	[21,30]
80	12312	JB	65-8-82-10-J	1-Jun-95	1-	20-Aug-91	1-			(0,30)+
81	12312	JB	65-8-82-11-J			30-Sep-91	1-			(0,30)+
82	12312	JB	65-8-82-12-J	1-Jun-95	1-	15-Oct-91	0		already selected by SF	[21,30]
83	12312	JB	65-8-82-9-J			30-Sep-91	1-			(0,30)+
84	12312	JB	65-8-87-5-J	6-Jun-95	1??	6-Sep-91	0		already selected by SF	[21,30]
85	12312	JB	65-8-87-6-J	1-Jun-95	1-	17-Oct-91	0		already selected by SF	[21,30]
86	12312	JB	65-8-92-13-J			9-Sep-91	1	1983		[11,22], [0,8)+
87	12312	JB	65-8-92-14-J			10-Jun-92				(0,30)+
88	12312	JB	65-8-92-15-J			10-Jun-92				(0,30)+
89	12312	JB	65-8-92-16-J			24-Oct-91	1-			(0,30)+
90	12312	JOB	65-8-167-10-J	7-Apr-95	1-	13-Sep-91	1-	1982	rt censure @ 13	[11,18], [0,13)+
91	12312	JOB	65-8-167-7-J	11-Apr-95	1-	30-Sep-91	0	1986	two failures (1986, 1995) ***	[19,25], [0,10]
92	12312	JOB	65-8-176-10-J			10-Jun-92				(0,30)+
93	12312	JOB	65-8-176-11-J	17-May-95	1-	10-Jun-92			already selected by SF	[21,30]
94	12312	JOB	65-8-176-12-J	21-Apr-95	1	10-Jun-92		1983	rt censure @ 13	[11,22], [0,13)+
95	12312	JOB	65-8-186-5-J	25-Apr-95	1	13-Sep-91	1-			[0,34)+
96	12312	JOB	65-8-186-6-J	10-May-95	1-	19-Sep-91	1-		already selected by SF	[21,30]
97	12312	JOB	65-8-191-3-J	5-Apr-95	1-	23-Sep-91	1			[0,34)+
98	12312	JOB	65-8-191-4-J	17-May-95	1	19-Jul-92	0		already selected by SF	[21,30]
99	12312	JOB	65-8-205-13-J	7-Apr-95	1	11-Jun-92	1	1982	rt censure @ 13	[11,18], [0,13)+
100	12312	JOB	65-8-27-0-J			29-May-92	1	1-Jan-89	ok @ 79 COH	[21,28]
101	12312	JOB	65-8-57-5-J			26-Sep-91	1-	1982	***	[11,18], [0,13)+
102	12312	JOB	65-8-57-6-J			24-Jun-92	1	1/1/1989,1982	two failures (1989, 1982)***	[11,18], [0,7]
103	12312	JOB	65-8-67-3-J			5-Aug-92	1			(0,30)+
104	12312	JOB	65-8-67-4-J			30-Sep-91	1	1/1/1989, 1983	two failures (1983, 1989) ***	[11,22], [0,7]
105	12312	JOB	65-8-77-6-J			18-Jun-91	1-			(0,30)+
106	12312	JOB	65-8-87-7-J	10-Apr-95	1-	15-Oct-91	1		already selected by SF	[30,34]
107	12312	JOB	66-8-87-8-J	6-Apr-95	0	15-Oct-91	0		already selected by SF	[21,30]
108	12312	JP	65-5-205-5-J			17-Oct-91	1-			(0,30)+
109	12312	JP	65-8-167-1-J			10-Jun-92				(0,30)+
110	12312	JP	65-8-167-2-J			10-Jun-92				(0,30)+
111	12312	JP	65-8-167-4-J			10-Jun-92				(0,30)+
112	12312	JP	65-8-169-0-J			10-Jun-92				(0,30)+
113	12312	JP	65-8-176-1-J			10-Jun-92	1			(0,30)+
114	12312	JP	65-8-176-2-J			10-Jun-92				(0,30)+
115	12312	JP	65-8-176-3-J			10-Jun-92				(0,30)+
116	12312	JP	65-8-176-4-J			13-Sep-91	1			(0,30)+
117	12312	JP	65-8-186-1-J			11-Jun-92				(0,30)+
118	12312	JP	65-8-186-2-J			11-Jun-92		1982	***	[11,18]
119	12312	JP	65-8-186-3-J			11-Jun-92		1982	***	[11,18]
120	12312	JP	65-8-186-4-J			11-Jun-92				(0,30)+
121	12312	JP	65-8-32-0-J			23-Sep-91	1	1982	***	[11,18], [0,10)+
122	12312	JP	65-8-37-0-J			23-Sep-91	1	1982	***	[11,18], [0,10)+
123	12312	JP	65-8-42-0-J			23-Jun-92		1983	***	[11,22]
124	12312	JP	65-8-52-1-J			21-Jul-92	1	1982	***	[11,18], [0,10)+
125	12312	JP	65-8-52-2-J			24-Jun-92	1-	1982	***	[11,18], [0,10)+
126	12312	JP	65-8-62-1-J			1-Oct-91	0	1982	two failures (1982, 1991) ***	[11,18], [0,10]
127	12312	JP	65-8-62-2-J			28-Oct-91	0	1982	two failures (1982, 1991) ***	[11,18], [0,10]
128	12312	JP	65-8-72-2-J			10-Aug-92	0	1982	two failures (1982, 1991) ***	[11,18], [0,10]
129	12312	JP	65-8-79-0-J	1-Jun-95	1??	12-Aug-92	1		already selected by SF	[28,32]
130	12312	JP	65-8-79-1-J			24-Oct-91				(0,30)+
131	12312	JP	65-8-82-1-J			10-Aug-92	1			(0,30)+
132	12312	JP	65-8-82-2-J	1994		8-Jul-92	0	1994	painted NNS 1994	[21,30]
133	12312	JP	65-8-82-3-J	31-May-95	1-	5-Aug-92	1		already selected by SF	[28,32]
134	12312	JP	65-8-82-4-J			10-Aug-92	1		suspended at 20 (1991)	(0,30)+
135	12312	JP cost	65-8-119-4-J			10-Jun-92	1	1986		[19,24], [0,6)+
136	12312	JP FO	65-8-129-1-J	1994				1994	painted NNS 1994	[21,30]
137	12312	JP FO	65-8-129-2-J					1982	***	[11,18]
138	12312	JP FO	65-8-130-2-J	1994		2-Jun-92		1994	painted NNS 1994	[21,30]
139	12312	JP FOB	65-8-115-11-J			10-Jun-92	0	1-Jan-85	two failures (1985, 1991), painted NNS 1994	[19,23], [0,7]
140	12312	JP FOB	65-8-115-13-J			10-Jun-92	0	1-Jan-85	two failures (1985, 1991), painted NNS 1994	[19,23], [0,7]
141	12312	JP FOB	65-8-115-14-J			10-Jun-92		1983	***	[11,22]
142	12312	JP FOB	65-8-115-16-J			19-Sep-91	1			(0,30)+
143	12312	JP FOB	65-8-120-10-J			19-Sep-91	1			(0,30)+
144	12312	JP FOB	65-8-125-10-J			19-Sep-91	1			(0,30)+
145	12312	JP FOB	65-8-125-7-J			10-Jun-92	0	1-Jan-85	two failures (1985, 1991), painted NNS 1994	[19,23], [0,7]
146	12312	JP FOB	65-8-129-9-J			23-Sep-91		1-Jan-85		[19,23]

APPENDIX A.7. CVN-65 JP-5 TANK HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
147	SWLIN	SERV	TANK	INS date	COND	INS date	COND	PAINTED	COMMENTS	INTERVALS
148				last known		previous				
149	12312	JP FOB	65-8-130-10-J			10-Jun-92				(0,30)+
150	12312	JP FOB	65-8-134-10-J			20-Sep-91	1			(0,30)+
151	12312	JP FOB	65-8-134-7-J			10-Jun-92		1982	***	[11,18]
152	12312	JP FOB	65-8-134-8-J			27-Sep-91	1			(0,30)+
153	12312	JP FOB	65-8-134-9-J			10-Jun-92				(0,30)+
154	12312	JP FOOB	65-8-120-12-J	25-May-95	1	19-Sep-91	1		rt censured @ 32	[0,34)+
155	12312	JP FOOB	65-8-120-7-J	25-May-95	1	10-Jun-92	0	1985	two failures (1985,1991), painted NNS 1994	[19,23], [0,7]
156	12312	JP FOOB	65-8-120-9-J			1-Jan-85	1	1-Jan-85	two failures (1985,1991), painted NNS 1994	[19,23], [0,7]
157	12312	JP FOOB	65-8-125-8-J	4-Apr-95	1	19-Sep-91	1		rt censured @ 32	[0,34)+
158	12312	JP FOOB	65-8-129-11-J	6-Apr-95	0	10-Jun-92		1985	two failures (1985,1995) already selected by SF	[19,23], [0,10]
159	12312	JP FOOB	65-8-130-12-J	21-Apr-95	1??				already selected by SF	[30,34]
160	12312	JP5 SUMP	65-8-138-5-F					1982, 1994	painted NNS 1994	[11,18], [0,10]
161	12312	JP5 SUMP	65-8-152-2-F					1982, 1994	painted NNS 1994	[11,18], [0,10]
162	12317	COST	65-8-204-1-J	13-Jun-95	1	16-Sep-91	0	1982	2 failures (1982,1991)	[11,18], [0,10]
163	12321	JP FOB	65-8-125-9-J			20-Sep-91	1	1-Jan-85		[19,23], [0,6)+
164	12312	JP SERV	65-8-195-10-J			19-Jul-92	0	painted NNS 1994	0k @ 87 DSRA	[26,30]
165	12312	JP SERV	65-8-195-11-J			19-Jul-92	0	painted NNS 1994	0k @ 87 DSRA	[26,30]
166	12312	JP SERV	65-8-195-12-J	5-Apr-95	1	19-Jul-92	0	painted NNS 1994	0k @ 87 DSRA	[26,30]
167	12312	JP SERV	65-8-195-9-J			19-Jul-92	0	1/1/1985, 1994		[19,23],[0,8]
168	12312	JP SERV	65-8-200-3-J	5-Apr-95	1	19-Jul-92	0	painted NNS 1994	0k @ 87 DSRA	[26,30]
169	12312	JP SERV	65-8-200-4-J			19-Jul-92	0	1983, 1994		[11,21],[0,10]
170	12312	JP SERV	65-8-200-5-J			19-Jul-92	0	painted NNS 1994	already selected by SF	[26,30]
171	12312	JP SERV	65-8-200-6-J			19-Jul-92	0	painted NNS 1994	0k @ 87 DSRA	[26,30]
172	12312	JP SERV	65-8-42-1-J	3-Apr-95	1			8-Jul-91	0k @ 87 DSRA	[26,30]
173	12312	JP SERV	65-8-42-2-J			1-Jun-92	1		0k @ 87 DSRA	[26,30]
174	12312	JP SERV	65-8-42-3-J			1-Jun-92	1	1982, 10/20/1991		[11,18],[0,9]
175	12312	JP SERV	65-8-47-3-J	4-Apr-95	1	28-Jun-92	1-		already selected by SF	[26,30]
176	12312	JP SERV	65-8-47-4-J			24-Jun-92	1	1/1/1989 1983		[11,21],[0,7]
177	12312	JP SERV	65-8-52-5-J	4-Apr-95	1-	10-Jul-92	1	1982	already selected by SF	[11,18], [0,10]
178	12312	JP SERV	65-8-52-6-J			1-Oct-91	1	1/1989 1982	intermediate L = 7yrs	[11,19],[0,8]

APPENDIX A.8. CVN-65 DAMAGE & LIST CONTROL VOID HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
1	SWLIN	SERVICE	TANK	INS date	COND	INS date	COND	PAINTED	COMMENTS	INTERVALS
2	12321	VOID DC	65-8-120-11-V			1-Jan-85		1-Jan-85	dont assume(poss id in 79 coh)	[0,23]
3	12321	VOID DC	65-8-143-12-V			25-May-91	1-			[0,30)+
4	12321	VOID DC	65-8-143-6-V			24-Oct-91	0		paint in very poor condition (vreeland)	[21,30]
5	12321	VOID DC	65-8-157-10-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
6	12321	VOID DC	65-8-157-13-V			1-Jan-86		1-Jan-86		[0,23]
7	12321	VOID DC	65-8-157-16-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
8	12321	VOID DC	65-8-157-5-V			26-Apr-91	1-	1986		[0,23]
9	12321	VOID DC	65-8-157-7-V			12-Jun-92	1-	1-Jan-86		[0,23]
10	12321	VOID DC	65-8-157-8-V	17-May-95	1	19-Jul-92	0	1994 (NNS) 1982		[0,18], [0,10]
11	12321	VOID DC	65-8-162-10-V			4-Jun-91	0		assume ok @ 79 COH	[21,30]
12	12321	VOID DC	65-8-162-13-V			3-Jun-91	1-	1986		[0,24] , [0,5)+
13	12321	VOID DC	65-8-162-16-V			19-Jul-92	0		assume ok @ 79 COH	[21,30]
14	12321	VOID DC	65-8-162-7-V			8-Jul-91	1-	1986		[0,23]
15	12321	VOID DC	65-8-162-8-V			23-May-91	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
16	12321	VOID DC	65-8-167-11-V			18-Apr-91	0	1986		[0,23]
17	12321	VOID DC	65-8-167-14-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
18	12321	VOID DC	65-8-167-3-V			20-Jun-91	1	1986		[0,23], [0,5)+
19	12321	VOID DC	65-8-167-5-V			17-Jun-91	1-	1986		[0,23], [0,5)+
20	12321	VOID DC	65-8-167-6-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
21	12321	VOID DC	65-8-167-8-V	3-May-95	1	19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
22	12321	VOID DC	65-8-171-1-V			1-Jan-86	0	1986, 1994		[0,23]
23	12321	VOID DC	65-8-171-2-V				0	1979, 1994		[0,18], [0,10]
24	12321	VOID DC	65-8-171-10-V	3-May-95	1	19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
25	12321	VOID DC	65-8-171-3-V			16-Aug-91	1	1986		[0,24], [0,5)+
26	12321	VOID DC	65-8-171-4-V	27-Apr-95	1	19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
27	12321	VOID DC	65-8-171-9-V			15-Aug-91		1986		[0,23]
28	12321	VOID DC	65-8-176-13-V			19-Jul-92	0	1994	assume ok @ 79 COH	[21,30]
29	12321	VOID DC	65-8-176-14-V	26-Apr-95	1	19-Jul-92	0	1994	assume ok @ 79 COH	[21,30]
30	12321	VOID DC	65-8-176-5-V			19-Jul-92	0	1994	assume ok @ 79 COH	[21,30]
31	12321	VOID DC	65-8-176-6-V			19-Jul-92	0	1994	assume ok @ 79 COH	[21,30]
32	12321	VOID DC	65-8-176-7-V			19-Jul-92	0	1994	assume ok @ 79 COH	[21,30]
33	12321	VOID DC	65-8-176-8-V			5-Sep-91	1	1982		[0,18] , [0,10)+
34	12321	VOID DC	65-8-181-1-V			19-Jul-92	0	1994	assume ok @ 79 COH	[21,30]
35	12321	VOID DC	65-8-181-2-V	3-May-95	0	14-Sep-91	0	1991 (SF)	already selected by SF, wrong paint	[21,30]
36	12321	VOID DC	65-8-181-7-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
37	12321	VOID DC	65-8-181-8-V	26-Apr-95	1	19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
38	12321	VOID DC	65-8-186-10-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
39	12321	VOID DC	65-8-186-9-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
40	12321	VOID DC	65-8-191-5-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
41	12321	VOID DC	65-8-191-6-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
42	12321	VOID DC	65-8-195-13-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
43	12321	VOID DC	65-8-195-14-V	25-Apr-95	0	11-Sep-91	0		assume ok @ 79 COH	[21,30]
44	12321	VOID DC	65-8-200-8-V	25-Apr-95	1-	9-Sep-91	0	3-Oct-91 (SF)	assume ok @ 79 COH	[21,30]
45	12321	VOID DC	65-8-42-6-V			28-Jun-92	1	1-Jan-89	assume ok @ 79 COH	[21, 28] , [0,3)+
46	12321	VOID DC	65-8-47-7-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
47	12321	VOID DC	65-8-47-8-V			22-Jun-92	1	1-Jan-89	assume ok @ 79 COH	[21, 28] , [0,3)+
48	12321	VOID DC	65-8-52-10-V			24-Jun-92	1	1-Jan-89	assume ok @ 79 COH	[21, 28] , [0,3)+
49	12321	VOID DC	65-8-52-3-V			16-Aug-91	1	1981		[0,18] , [0,10)+
50	12321	VOID DC	65-8-52-4-V	25-Apr-95	1	16-Aug-91	1	1981		[0,18] , [0,10)+
51	12321	VOID DC	65-8-52-9-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
52	12321	VOID DC	65-8-57-1-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
53	12321	VOID DC	65-8-57-2-V			16-Aug-91	1			[0,30)+
54	12321	VOID DC	65-8-57-7-V			19-Aug-91	1			[0,30)+
55	12321	VOID DC	65-8-57-8-V			24-Jun-92	1			[0,30)+
56	12321	VOID DC	65-8-62-3-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
57	12321	VOID DC	65-8-62-4-V			17-Jul-91		1981		[0,18]
58	12321	VOID DC	65-8-64-1-V			19-Aug-91	0		assume ok @ 79 COH	[21,30]
59	12321	VOID DC	65-8-64-2-V			29-Jul-92	1			[0,30)+
60	12321	VOID DC	65-8-67-1-V			5-Aug-92	1	1981		[0,18] , [0,10)+
61	12321	VOID DC	65-8-67-2-V			5-Aug-92	1	1981		[0,18] , [0,10)+
62	12321	VOID DC	65-8-67-7-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
63	12321	VOID DC	65-8-67-8-V			29-Jul-92	1	1-Jan-89	assume ok @ 79 COH	[21, 28] , [0,3)+
64	12321	VOID DC	65-8-72-1-V			8-Jul-92	0	1994 (NNS) 1983		[0,22] , [0,10]
65	12321	VOID DC	65-8-72-12-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
66	12321	VOID DC	65-8-72-3-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
67	12321	VOID DC	65-8-72-4-V			5-Aug-92	1			[0,30)+
68	12321	VOID DC	65-8-72-6-V			5-Aug-92	1-	1-Feb-92 (SF)	assume ok @ 79 COH	[21,30]
69	12321	VOID DC	65-8-72-9-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
70	12321	VOID DC	65-8-77-1-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
71	12321	VOID DC	65-8-77-10-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
72	12321	VOID DC	65-8-77-2-V			14-Aug-91	1-			[0,30)+
73	12321	VOID DC	65-8-77-3-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]

APPENDIX A.8. CVN-65 DAMAGE & LIST CONTROL VOID HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
74	SWLIN	SERVICE	TANK	INS date	COND	INS date	COND	PAINTED	COMMENTS	INTERVALS
75	12321	VOID DC	65-8-77-4-V			14-Aug-91	1-			[0,30)+
76	12321	VOID DC	65-8-77-9-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
77	12321	VOID DC	65-8-82-13-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
78	12321	VOID DC	65-8-82-14-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
79	12321	VOID DC	65-8-82-5-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
80	12321	VOID DC	65-8-82-6-V			8-Mar-91	1-			[0,30)+
81	12321	VOID DC	65-8-82-7-V			8-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
82	12321	VOID DC	65-8-82-8-V			8-Mar-91	0			[21,30]
83	12321	VOID DC	65-8-87-1-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
84	12321	VOID DC	65-8-87-10-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
85	12321	VOID DC	65-8-87-2-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
86	12321	VOID DC	65-8-87-3-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
87	12321	VOID DC	65-8-87-4-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
88	12321	VOID DC	65-8-87-9-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
89	12321	VOID DC	65-8-92-10-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
90	12321	VOID DC	65-8-92-12-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
91	12321	VOID DC	65-8-92-18-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
92	12321	VOID DC	65-8-97-12-V			11-Jun-92		1-Jan-79		[0,18]
93	12321	VOID DC	65-8-97-4-V	5-May-95	1	11-Jun-92		1994 (NNS)	assume ok @ 79 COH	[21,30]
94	12321	VOID DC	65-8-97-6-V			15-Oct-91	1-			[0,30)+
95	12321	VOID DC	65-8-97-7-V			12-Aug-92	1	1985		[0,23] , [0,7)+
96	12313	PEAK SWB	65-8-5-0-W			26-May-92	0	1991, 1975	like 8-C-0-W	[0,14] , [0,16]
97	12313	PEAK SWB	65-8-C-0-W	15-May-95	1	26-May-92	0	1991, 1/1979, 1968	more like floodable void	[0,7] , [0,11], [0,10]
98	12321	DC/OW	65-8-134-11-W					1-Jan-79		[0,18]
99	12321	DC/OW	65-8-134-12-V					1-Jan-79		[0,18]
100	12321	DC/OW	65-8-134-3-W					1-Jan-79		[0,18]
101	12321	DC/OW	65-8-134-4-W					1-Jan-79		[0,18]
102	12321	DC/OW	65-8-134-5-W					1-Jan-79		[0,18]
103	12321	DC/OW	65-8-134-6-W					1-Jan-79		[0,18]
104	12321	FW BLST	65-8-115-0-W			26-May-92		1979, 1991	Reactor space	[0,18], [0,10]
105	12321	FW BLST	65-8-115-1-W			26-May-92		1979, 1991	Reactor space	[0,18], [0,10]
106	12321	FW BLST	65-8-138-0-W			26-May-92		1991	Reactor space	[21,30]
107	12321	FW BLST	65-8-138-4-W			26-May-92		1979, 1991	Reactor space	[0,18], [0,10]
108	12321	FW BLST	65-8-152-0-W			26-May-92		1979, 1991	Reactor space	[0,18], [0,10]
109	12321	FW BLST	65-8-152-1-W			26-May-92		1979, 1991	Reactor space	[0,18], [0,10]
110	12321	FW BLST	65-8-92-0-W			26-May-92		1979, 1991	Reactor space	[0,18], [0,10]
111	12321	FW BLST	65-8-92-4-W			26-May-92		1979, 1991	Reactor space	[0,18], [0,10]
112	12313	FW BLST	65-8-115-0-W					1979	Reactor space	[0,18]
113	12321	VOID DC(LC)	65-8-102-11-V			13-Aug-91	0	2-Jan-85		[0,23], [0,7]
114	12321	VOID DC(LC)	65-8-102-12-V			11-Jun-92	1	1982		[0,18],[0,10)+
115	12321	VOID DC(LC)	65-8-102-3-V			16-Aug-91	1	1985		[0,23], [0,7)+
116	12321	VOID DC(LC)	65-8-102-5-V			10-Jul-91	1	1-Jan-85		[0,23], [0,7)+
117	12321	VOID DC(LC)	65-8-102-6-V			15-Oct-91	0		assume ok @ 79 COH	[21,30]
118	12321	VOID DC(LC)	65-8-106-10-V	17-May-95	1	10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
119	12321	VOID DC(LC)	65-8-106-13-V			23-Jul-91	1-	1985		[0,23], [0,6)+
120	12321	VOID DC(LC)	65-8-106-16-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
121	12321	VOID DC(LC)	65-8-106-5-V			10-Jul-92	0	1/1/1985		[0,23] , [0,7]
122	12321	VOID DC(LC)	65-8-106-7-V			10-Aug-92	1-	1985		[0,23], [0,6)+
123	12321	VOID DC(LC)	65-8-106-8-V			8-Jul-92	0	1/1/1979, 1994		[0,18] , [0,10]
124	12321	VOID DC(LC)	65-8-111-11-V			12-Aug-92	1	1985		[0,23], [0,6)+
125	12321	VOID DC(LC)	65-8-111-12-V			11-Jun-92	1			[0,30)+
126	12321	VOID DC(LC)	65-8-111-3-V			1-Jan-85	1	1-Jan-85		[0,23], [0,6)+
127	12321	VOID DC(LC)	65-8-111-4-V	5-May-95	1	28-May-92	1	1/1/1979		[0,18] , [0,10)+
128	12321	VOID DC(LC)	65-8-111-5-V			12-Aug-92	1	1-Jan-85		[0,23] , [0,7)+
129	12321	VOID DC(LC)	65-8-111-6-V			11-Jun-92	1-			[0,30)+
130	12321	VOID DC(LC)	65-8-115-10-V			1-Mar-91	1-			[0,30)+
131	12321	VOID DC(LC)	65-8-115-12-V			12-Aug-92	1			[0,30)+
132	12321	VOID DC(LC)	65-8-115-15-V			1-Jan-85		1-Jan-85		[0,23]
133	12321	VOID DC(LC)	65-8-115-18-V							[0,30)+
134	12321	VOID DC(LC)	65-8-115-7-V			1-Jan-85		1-Jan-85		[0,23]
135	12321	VOID DC(LC)	65-8-115-9-V			1-Jan-85		1-Jan-85	vp cond (vreeland)	[0,23] , [0,7]
136	12321	VOID DC(LC)	65-8-120-14-V			6-May-91	1-			[0,30)+
137	12321	VOID DC(LC)	65-8-120-5-V			8-Jul-92	1	1-Jan-85		[0,23] , [0,7)+
138	12321	VOID DC(LC)	65-8-120-6-V			11-Jun-92	1			[0,30)+
139	12321	VOID DC(LC)	65-8-120-8-V			12-Aug-92	1			[0,30)+
140	12321	VOID DC(LC)	65-8-125-11-V			12-Aug-92	1	1985		[0,23] , [0,7)+
141	12321	VOID DC(LC)	65-8-125-12-V			14-Aug-91	1			[0,30)+
142	12321	VOID DC(LC)	65-8-125-3-V			8-Jul-92	1	1-Jan-85		[0,23] , [0,7)+
143	12321	VOID DC(LC)	65-8-125-4-V			1-Mar-91	1	1-Jan-85		[0,23] , [0,7)+
144	12321	VOID DC(LC)	65-8-125-5-V			1-Jan-85	1-	1-Jan-85		[0,23] , [0,7)+
145	12321	VOID DC(LC)	65-8-125-6-V			10-Jul-91	1-			[0,30)+
146	12321	VOID DC(LC)	65-8-129-13-V			15-Aug-91	1-	1985		[0,23] , [0,7)+

APPENDIX A.8. CVN-65 DAMAGE & LIST CONTROL VOID HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
147	SWLIN	SERVICE	TANK	INS date	COND	INS date	COND	PAINTED	COMMENTS	INTERVALS
148	12321	VOID DC(LC)	65-8-129-5-V			1-Jan-85	1-	1-Jan-85		[0,23] , [0,7)+
149	12321	VOID DC(LC)	65-8-129-7-V			12-Aug-92	1	1-Jan-85		[0,23] , [0,7)+
150	12321	VOID DC(LC)	65-8-130-14-V			11-Jun-92				[0,30)+
151	12321	VOID DC(LC)	65-8-130-6-V			11-Jun-92				[0,30)+
152	12321	VOID DC(LC)	65-8-130-8-V			11-Jun-92				[0,30)+
153	12321	VOID DC(LC)	65-8-138-10-V			12-Jun-92		1994	assume ok @ 79 COH	[21,30]
154	12321	VOID DC(LC)	65-8-138-11-V			15-Aug-91	1-	1986		[0,23] , [0,7)+
155	12321	VOID DC(LC)	65-8-138-12-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
156	12321	VOID DC(LC)	65-8-138-17-V			15-Aug-91	1	1986		[0,23] , [0,7)+
157	12321	VOID DC(LC)	65-8-138-18-V			8-Mar-91	1-			[0,30)+
158	12321	VOID DC(LC)	65-8-138-9-V			15-Aug-91	1	1986		[0,23] , [0,7)+
159	12321	VOID DC(LC)	65-8-143-13-V			15-Aug-91	1	1986		[0,23] , [0,7)+
160	12321	VOID DC(LC)	65-8-143-5-V			15-Aug-91	1	1986		[0,23] , [0,7)+
161	12321	VOID DC(LC)	65-8-143-7-V			15-Aug-91	1	1986		[0,23] , [0,7)+
162	12321	VOID DC(LC)	65-8-148-11-V			20-Aug-91	1	1986		[0,23] , [0,7)+
163	12321	VOID DC(LC)	65-8-148-12-V			20-Aug-91	1			[0,30)+
164	12321	VOID DC(LC)	65-8-148-3-V	16-May-95	1-	19-Aug-91	1	1986		[0,23] , [0,7)+
165	12321	VOID DC(LC)	65-8-148-4-V			5-Mar-91	0	1994		[0,30)+
166	12321	VOID DC(LC)	65-8-148-5-V			30-Jul-91	1-	1986		[0,23] , [0,7)+
167	12321	VOID DC(LC)	65-8-148-6-V			19-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
168	12321	VOID DC(LC)	65-8-152-10-V			3-Jun-91	1-			[0,30)+
169	12321	VOID DC(LC)	65-8-152-15-V			19-Aug-91	1	1986		[0,23] , [0,7)+
170	12321	VOID DC(LC)	65-8-152-16-V			12-Jun-92	1			[0,30)+
171	12321	VOID DC(LC)	65-8-152-7-V			19-Aug-91	1	1986		[0,23] , [0,7)+
172	12321	VOID DC(LC)	65-8-152-8-V			3-Jun-91	1-			[0,30)+
173	12321	VOID DC(LC)	65-8-152-9-V			4-Jun-91	0	1986		[0,23] , [0,7)+
174	12321	VOID DC(LC)	65-8-92-11-V	27-Apr-95	1	10-Jul-92	0	1982, 1994 (NNS)		[0,18] , [0,10]
175	12321	VOID DC(LC)	65-8-92-17-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
176	12321	VOID DC(LC)	65-8-92-9-V			10-Jul-92	0	1994 (NNS)	assume ok @ 79 COH	[21,30]
177	12321	VOID DC(LC)	65-8-97-13-V			13-Aug-91	1-	1985		[0,23] , [0,7)+
178	12321	VOID DC(LC)	65-8-97-5-V			13-Aug-91	1	1985		[0,23] , [0,7)+

APPENDIX A.9. CVN-65 DRY VOID & COFFERDAM HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
1	SWLIN	SERV	TANK	INS Date	COND	INS Date	COND	PAINTED	COMMENTS	INTERVALS
2	12321	CD	65-8-102-1-V			2-Oct-91	0		Machinery Box	[0,30]
3	12321	CD	65-8-102-2-V			26-May-92		1994	Machinery Box	[0,30]
4	12321	CD	65-8-106-2-V			28-Oct-91	0	1994		[0,30]
5	12321	CD	65-8-106-3-V			10-Oct-91	0	1982	Machinery Box	[0,18],[0,10]
6	12321	CD	65-8-106-6-V			13-Oct-91	0	1985, 1994	Machinery Box	[0,24],[0,6]
7	12321	CD	65-8-111-1-V			10-Oct-91	0	1982	Machinery Box	[0,18],[0,10]
8	12321	CD	65-8-111-2-V			11-Oct-91	0		Machinery Box	[0,30]
9	12321	CD	65-8-113-0-V			27-Oct-91	0	1994		[0,30]
10	12321	CD	65-8-115-5-V					1994	Machinery Box	[0,30]
11	12321	CD	65-8-115-8-V			1-Oct-91	0	1994	Machinery Box	[0,30]
12	12321	CD	65-8-120-1-V					1994	Machinery Box	[0,30]
13	12321	CD	65-8-120-4-V			7-Oct-91	0	1994	Machinery Box	[0,30]
14	12321	CD	65-8-125-1-V					1994	Machinery Box	[0,30]
15	12321	CD	65-8-125-2-V			20-Aug-91	1	1994	Machinery Box	[0,30]
16	12321	CD	65-8-129-0-V					1994		[0,30]
17	12321	CD	65-8-129-3-V			17-Oct-91	0	1994	Machinery Box	[0,30]
18	12321	CD	65-8-130-4-V			2-Jun-92		1994		[0,30]
19	12321	CD	65-8-134-1-V			7-Oct-91	0	1994	Machinery Box	[0,30]
20	12321	CD	65-8-134-2-V					1994	Machinery Box	[0,30]
21	12321	CD	65-8-136-2-V							
22	12321	CD	65-8-138-7-V			4-Sep-91	0	1994	Machinery Box	[0,30]
23	12321	CD	65-8-138-8-V					1994	Machinery Box	[0,30]
24	12321	CD	65-8-143-2-V					1994	Machinery Box	[0,30]
25	12321	CD	65-8-143-3-V			5-Oct-91	0		Machinery Box	[0,30]
26	12321	CD	65-8-148-1-V			5-Oct-91	0		Machinery Box	[0,30]
27	12321	CD	65-8-148-2-V						Machinery Box	
28	12321	CD	65-8-152-5-V						Machinery Box	
29	12321	CD	65-8-152-6-V			4-Oct-91	0	1994	Machinery Box	[0,30]
30	12321	CD	65-8-157-3-V					1994	Machinery Box	[0,30]
31	12321	CD	65-8-157-6-V			5-Oct-91	0	1994	Machinery Box	[0,30]
32	12321	CD	65-8-162-3-V			12-Jun-92		1994	Machinery Box	[0,30]
33	12321	CD	65-8-162-6-V			5-Oct-91	0	1994	Machinery Box	[0,30]
34	12321	CD	65-8-167-0-V			11-May-93				
35	12321	CD	65-8-90-2-V			10-Jul-92	0	1994, 1982		[0,18],[0,10]
36	12321	CD	65-8-92-7-V			2-Oct-91	1		Machinery Box	[0,30)+
37	12321	CD	65-8-92-8-V					1994	Machinery Box	[0,30]
38	12321	CD	65-8-97-2-V					1994	Machinery Box	[0,30]
39	12321	CD	65-8-97-3-V			3-Oct-91	0	1994	Machinery Box	[0,30]
40	12321	V	65-8-72-01-G					1994	old AVGAS	[0,30]
41	12321	V	65-8-73-0-J					1994	old AVGAS	[0,30]
42	12321	V	65-8-74-0-J					1994	old AVGAS	[0,30]
43	12321	VOID	65-4-102-1-V			13-Aug-91	0	3-Sep-91 (SF)	bottom totally gone!	[0,30]
44	12321	VOID	65-4-102-2-V	5-May-95	1- ??	2-Apr-91	0			[0,30]
45	12321	VOID	65-4-102-3-V			12-Feb-91	1			[0,30)+
46	12321	VOID	65-4-102-4-V			22-Feb-91	1	1994		[0,30]
47	12321	VOID	65-4-102-5-V	8-Jun-95	1	8-Jul-92	0	1994	wrong paint	[0,30]
48	12321	VOID	65-4-102-6-V	27-Apr-95	1	21-Feb-91	1-	1994	wrong paint	[0,30]
49	12321	VOID	65-4-106-10-V	17-Apr-95	1-	14-Aug-91	0	1994	wrong paint	[0,30]
50	12321	VOID	65-4-106-5-V			28-May-92	1			[0,30)+
51	12321	VOID	65-4-106-6-V			28-May-92	1			[0,30)+
52	12321	VOID	65-4-106-7-V			13-Aug-91	0	7-Oct-91 (SF)		[0,30]
53	12321	VOID	65-4-106-8-V	17-May-95	1-	15-Oct-91	0	1994	wrong paint	[0,30]
54	12321	VOID	65-4-106-9-V	10-May-95	1-	15-Aug-91	1-	1994	wrong paint	[0,30]
55	12321	VOID	65-4-107-2-V							
56	12321	VOID	65-4-107-3-V							
57	12321	VOID	65-4-111-1-V			28-May-92	1			[0,30)+
58	12321	VOID	65-4-111-2-V	5-May-95	1-	28-May-92	1			[0,34)+
59	12321	VOID	65-4-111-3-V			13-Aug-91	1	3-Jul-91		[0,30)+
60	12321	VOID	65-4-111-4-V			28-May-92	1			[0,30)+
61	12321	VOID	65-4-111-5-V	9-May-95	1	13-Aug-91	1	7/22/1991 (SF)	wrong paint	[0,30]
62	12321	VOID	65-4-111-6-V	17-Apr-95	1	15-Aug-91	1	1991	wrong paint	[0,30]
63	12321	VOID	65-4-115-1-V			14-Feb-91	1-	1994		[0,30]
64	12321	VOID	65-4-115-10-V			3-Sep-91	1			[0,30)+
65	12321	VOID	65-4-115-12-V			3-Sep-91	1			[0,30)+
66	12321	VOID	65-4-115-3-V			15-Oct-91	0	1991		[0,30]
67	12321	VOID	65-4-115-5-V			15-Oct-91	0			[0,30]
68	12321	VOID	65-4-115-8-V			29-Jan-91	1			[0,30)+
69	12321	VOID	65-4-120-1-V			8-Jul-92	1			[0,30)+
70	12321	VOID	65-4-120-3-V			8-Jul-92	1			[0,30)+
71	12321	VOID	65-4-120-4-V			1-Feb-91	1			[0,30)+
72	12321	VOID	65-4-120-5-V	18-May-95	1	28-May-92		1982, 1991 (SF)	wrong paint	[0,18],[0,10]
73	12321	VOID	65-4-120-6-V			30-Jan-91	1			[0,30)+

APPENDIX A.9. CVN-65 DRY VOID & COFFERDAM HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
74	SWLIN	SERV	TANK	INS Date	COND	INS Date	COND	PAINTED	COMMENTS	INTERVALS
75	12321	VOID	65-4-120-8-V	18-May-95	1	14-Aug-91	1	1991 (SF)	wrong paint	[0,30]
76	12321	VOID	65-4-125-1-V			12-Jun-91	0	1991??		[0,30]
77	12321	VOID	65-4-125-2-V			31-Jan-91	1			[0,30)+
78	12321	VOID	65-4-125-3-V			20-Aug-91	0	1991??		[0,30]
79	12321	VOID	65-4-125-4-V			2-Jul-91	1			[0,30)+
80	12321	VOID	65-4-125-5-V			16-Aug-91	0	1991 (SF)	wrong paint	[0,30]
81	12321	VOID	65-4-125-6-V	18-Apr-95	1	14-Aug-91	1	1991 (SF)	wrong paint	[0,30]
82	12321	VOID	65-4-129-10-V							
83	12321	VOID	65-4-129-3-V			16-Aug-91	1-			[0,30)+
84	12321	VOID	65-4-129-4-V							
85	12321	VOID	65-4-129-5-V			28-May-92	1			[0,30)+
86	12321	VOID	65-4-129-6-V			7-May-91	1			[0,30)+
87	12321	VOID	65-4-129-7-V	17-Apr-95	1	15-Aug-91	0			[0,30]
88	12321	VOID	65-4-129-8-V	21-Apr-95	1	9-Apr-91	1	1991 (SF)	wrong paint	[0,30]
89	12321	VOID	65-4-134-1-V			14-Feb-91	0			[0,30]
90	12321	VOID	65-4-134-3-V			14-Aug-91	0	9-Sep-91 (SF)		[0,30]
91	12321	VOID	65-4-134-4-V			4-Feb-91	1			[0,30)+
92	12321	VOID	65-4-134-5-V			8-Jul-92	0	1994		[0,30]
93	12321	VOID	65-4-134-6-V			9-Apr-91	1	1982		[0,18]
94	12321	VOID	65-4-134-8-V			30-May-91	1			[0,30)+
95	12321	VOID	65-4-138-11-V	17-Apr-95	1	15-Aug-91	0	6/25/1991 (SF)	wrong paint	[0,30]
96	12321	VOID	65-4-138-2-V			28-May-92		1991		[0,30]
97	12321	VOID	65-4-138-4-V			15-Feb-91	1-	1991		[0,30]
98	12321	VOID	65-4-138-6-V	28-Apr-95	1	15-Feb-91	1-	1991 (SF)	wrong paint	[0,30]
99	12321	VOID	65-4-138-7-V			15-Aug-91	1			[0,30)+
100	12321	VOID	65-4-138-9-V			15-Aug-91	1			[0,30)+
101	12321	VOID	65-4-143-1-V			15-Aug-91	1			[0,30)+
102	12321	VOID	65-4-143-3-V			15-Aug-91	1	2-Jul-91		[0,30]
103	12321	VOID	65-4-143-4-V			14-Feb-91	1			[0,30)+
104	12321	VOID	65-4-143-6-V			14-Feb-91	1	1982, 1991		[0,18],[0,10]
105	12321	VOID	65-4-143-8-V	2-May-95	1	15-Feb-91	1-	1991 (SF)	wrong paint	[0,30]
106	12321	VOID	65-4-148-1-V			19-Aug-91	1	22-Jun-91		[0,30]
107	12321	VOID	65-4-148-2-V			5-Feb-91	0	1991		[0,30]
108	12321	VOID	65-4-148-3-V			19-Aug-91	1	1991		[0,30]
109	12321	VOID	65-4-148-4-V			3-Jun-91	1	1991		[0,30]
110	12321	VOID	65-4-148-5-V	19-Apr-95		19-Aug-91	1	1982, 1991 (SF)	wrong paint	[0,18],[0,10]
111	12321	VOID	65-4-148-6-V	18-Apr-95		20-Aug-91	0	1991 (SF)	wrong paint	[0,30]
112	12321	VOID	65-4-152-1-V			19-Aug-91	1			[0,30)+
113	12321	VOID	65-4-152-10-V			5-Feb-91	1			[0,30)+
114	12321	VOID	65-4-152-12-V	19-Apr-95	1	5-Feb-91	1-	1991 (SF)	wrong paint	[0,30]
115	12321	VOID	65-4-152-3-V			19-Aug-91	1	1991		[0,30]
116	12321	VOID	65-4-152-5-V	19-Apr-95	1			1991 (SF)	wrong paint	[0,30]
117	12321	VOID	65-4-152-8-V			8-Apr-91	1			[0,30)+
118	12321	VOID	65-4-157-1-V			20-Feb-91	1-	1991		[0,30]
119	12321	VOID	65-4-157-3-V					1991		[0,30]
120	12321	VOID	65-4-157-4-V	17-May-95	1-	6-Feb-91	1-			[0,34)+
121	12321	VOID	65-4-157-5-V	5-May-95	1		1-	1991 (SF)	wrong paint	[0,30]
122	12321	VOID	65-4-157-6-V			6-Feb-91	1			[0,30)+
123	12321	VOID	65-4-157-8-V	20-Apr-95	1	8-Jul-92	0	1991 (SF)	wrong paint	[0,30]
124	12321	VOID	65-4-162-2-V			7-May-91	0			[0,30]
125	12321	VOID	65-4-162-3-V			22-Feb-91	1-			[0,30)+
126	12321	VOID	65-4-162-4-V			28-May-92	1			[0,30)+
127	12321	VOID	65-4-162-5-V			11-Feb-91	1-			[0,30)+
128	12321	VOID	65-4-162-6-V	12-Jun-95	1	8-Jul-92	0	1994		[0,30]
129	12321	VOID	65-4-162-7-V			13-Feb-91	1-			[0,30)+
130	12321	VOID	65-4-167-4-V			6-Feb-91	0			[0,30]
131	12321	VOID	65-4-167-5-V			13-Feb-91	0	26-Jun-91		[0,30]
132	12321	VOID	65-4-167-6-V	3-May-95	1-	20-Aug-91	1	1991 (SF)	wrong paint	[0,30]
133	12321	VOID	65-4-167-7-V			13-Feb-91	1-			[0,30)+
134	12321	VOID	65-4-167-8-V	18-Apr-95	1	8-Feb-91	0	1991 (SF)	wrong paint	[0,30]
135	12321	VOID	65-4-171-2-V			20-Aug-91	0			[0,30]
136	12321	VOID	65-4-171-3-V			20-Feb-91	1			[0,30)+
137	12321	VOID	65-4-171-4-V	27-Apr-95	1-	20-Aug-91	1			[0,30)+
138	12321	VOID	65-4-171-5-V			16-Aug-91	1			[0,30)+
139	12321	VOID	65-4-171-6-V			28-May-92	1			[0,30)+
140	12321	VOID	65-4-176-2-V			5-Sep-91	1-			[0,30)+
141	12321	VOID	65-4-176-3-V			5-Sep-91	1			[0,30)+
142	12321	VOID	65-4-176-4-V			5-Sep-91	1			[0,30)+
143	12321	VOID	65-4-176-5-V			5-Sep-91	1			[0,30)+
144	12321	VOID	65-4-181-1-V							
145	12321	VOID	65-4-181-2-V	11-Apr-95	0				already selected by SF	[0,30]
146	12321	VOID	65-4-181-3-V			5-Sep-91	1	1994		[0,30]

APPENDIX A.9. CVN-65 DRY VOID & COFFERDAM HISTORY FILE

	A	B	C	D	E	F	G	H	I	J
147	SWLIN	SERV	TANK	INS Date	COND	INS Date	COND	PAINTED	COMMENTS	INTERVALS
148	12321	VOID	65-4-181-4-V	4-May-95	1-	17-Sep-91	1	1991		[0,30]
149	12321	VOID	65-4-181-5-V			5-Sep-91	0	23-Sep-91		[0,30]
150	12321	VOID	65-4-186-2-V							
151	12321	VOID	65-4-186-3-V							
152	12321	VOID	65-4-186-4-V	10-May-95	1	19-Sep-91	1	1991 (SF)	wrong paint	[0,30]
153	12321	VOID	65-4-186-5-V	25-Apr-95	1	16-Sep-91	1	1991 (SF)	wrong paint	[0,30]
154	12321	VOID	65-4-186-7-V			5-Sep-91	0			[0,30]
155	12321	VOID	65-4-191-1-V							
156	12321	VOID	65-4-191-2-V							
157	12321	VOID	65-4-191-3-V			16-Sep-91	0			[0,30]
158	12321	VOID	65-4-191-4-V			17-Sep-91	1			[0,30)+
159	12321	VOID	65-4-195-1-V							
160	12321	VOID	65-4-195-2-V							
161	12321	VOID	65-4-195-3-V			12-Sep-91	0			[0,30]
162	12321	VOID	65-4-200-1-V	13-Jun-95	1	16-Sep-91	0			[0,30]
163	12321	VOID	65-4-200-2-V			16-Sep-91	0			[0,30]
164	12321	VOID	65-4-220-1-V			28-May-92	1			[0,30)+
165	12321	VOID	65-4-220-2-V							
166	12321	VOID	65-4-255-1-V							
167	12321	VOID	65-4-255-2-V							
168	12321	VOID	65-4-42-1-V							
169	12321	VOID	65-4-42-2-V			12-Jun-92	1			[0,30)+
170	12321	VOID	65-4-42-3-V	17-Apr-95	1-	19-Aug-91	1	1991 (SF)	wrong paint	[0,30]
171	12321	VOID	65-4-42-4-V			18-Jul-91	1			[0,30)+
172	12321	VOID	65-4-47-3-V	17-Apr-95	1	16-Sep-91	1	1991 (SF)	wrong paint	[0,30]
173	12321	VOID	65-4-47-4-V			11-Oct-91	1			[0,30)+
174	12321	VOID	65-4-52-1-V			16-Aug-91	1			[0,30)+
175	12321	VOID	65-4-52-2-V	24-Apr-95	1-	16-Aug-91	1	1982		[0,18], [0,13)+
176	12321	VOID	65-4-52-3-V	17-Apr-95	1	16-Aug-91	1	1991 (SF)	wrong paint	[0,30]
177	12321	VOID	65-4-52-4-V			16-Jul-91	1			[0,30)+
178	12321	VOID	65-4-57-1-V			16-Aug-91	0			[0,30]
179	12321	VOID	65-4-57-2-V			16-Aug-91	1	1982, 1991		[0,18],[0,10]
180	12321	VOID	65-4-57-3-V	19-May-95	1	13-Aug-91	0	1991 (SF)	wrong paint	[0,30]
181	12321	VOID	65-4-57-4-V			16-Jul-91	1			[0,30)+
182	12321	VOID	65-4-62-3-V			16-Aug-91	0			[0,30]
183	12321	VOID	65-4-62-5-V			23-Jul-91	0			[0,30]
184	12321	VOID	65-4-62-6-V			17-Jul-91	1			[0,30)+
185	12321	VOID	65-4-62-8-V			16-Jul-91	1			[0,30)+
186	12321	VOID	65-4-67-2-V			17-Jul-91	1			[0,30)+
187	12321	VOID	65-4-67-3-V			16-Aug-91	1			[0,30)+
188	12321	VOID	65-4-67-4-V			12-Jun-92	1			[0,30)+
189	12321	VOID	65-4-67-5-V			22-Jul-91	0			[0,30]
190	12321	VOID	65-4-72-1-V			12-Aug-91	1			[0,30)+
191	12321	VOID	65-4-72-3-V			12-Aug-91	1			[0,30)+
192	12321	VOID	65-4-72-4-V			12-Jun-92	1			[0,30)+
193	12321	VOID	65-4-72-6-V			12-Jun-92	1			[0,30)+
194	12321	VOID	65-4-77-1-V			12-Aug-91	1			[0,30)+
195	12321	VOID	65-4-77-3-V			12-Aug-91	1			[0,30)+
196	12321	VOID	65-4-77-4-V			23-Jan-91	0			[0,30]
197	12321	VOID	65-4-77-6-V			14-Aug-91	1			[0,30)+
198	12321	VOID	65-4-82-2-V			24-Jan-91	1			[0,30)+
199	12321	VOID	65-4-82-4-V			23-Jan-91	1-			[0,30)+
200	12321	VOID	65-4-82-5-V			12-Aug-91	0			[0,30]
201	12321	VOID	65-4-82-7-V			12-Aug-91	1			[0,30)+
202	12321	VOID	65-4-87-1-V			12-Aug-91	0			[0,30]
203	12321	VOID	65-4-87-2-V			14-Aug-91	1			[0,30)+
204	12321	VOID	65-4-87-3-V			7-Feb-91	1-	15-Jul-91		[0,30]
205	12321	VOID	65-4-87-4-V			24-Jan-91	1	19-Jul-91		[0,30]
206	12321	VOID	65-4-87-5-V							
207	12321	VOID	65-4-92-11-V	13-Jun-95	1	8-Jul-92	0	1994		[0,30]
208	12321	VOID	65-4-92-2-V			20-Aug-91	1	3-Jun-91		[0,30)+
209	12321	VOID	65-4-92-4-V			14-Aug-91	0			[0,30]
210	12321	VOID	65-4-92-6-V			8-Jul-92	0	1994		[0,30]
211	12321	VOID	65-4-92-7-V			13-Aug-91	1			[0,30)+
212	12321	VOID	65-4-92-9-V	27-Apr-95	1	13-Aug-91	1	6/18/1991 (NNS)		[0,30]
213	12321	VOID	65-4-97-2-V							
214	12321	VOID	65-4-97-3-V			13-Aug-91	1			[0,30)+
215	12321	VOID	65-4-97-4-V	5-May-95	0	21-Feb-91	1	1972	already selected by SF	[0,10] , [0,22]
216	12321	VOID	65-4-97-5-V			13-Aug-91	1	19-Jun-91		[0,30]
217	12321	VOID	65-4-97-6-V	26-Apr-95	1	15-Oct-91	1-	1991 (SF)	wrong paint	[0,30]
218	12321	VOID	65-4-97-7-V	9-May-95	1	13-Aug-91	0	7/27/1991 (SF)	wrong paint	[0,30]
219	12321	VOID	65-5-205-4-V			28-Oct-91	0			[0,30]

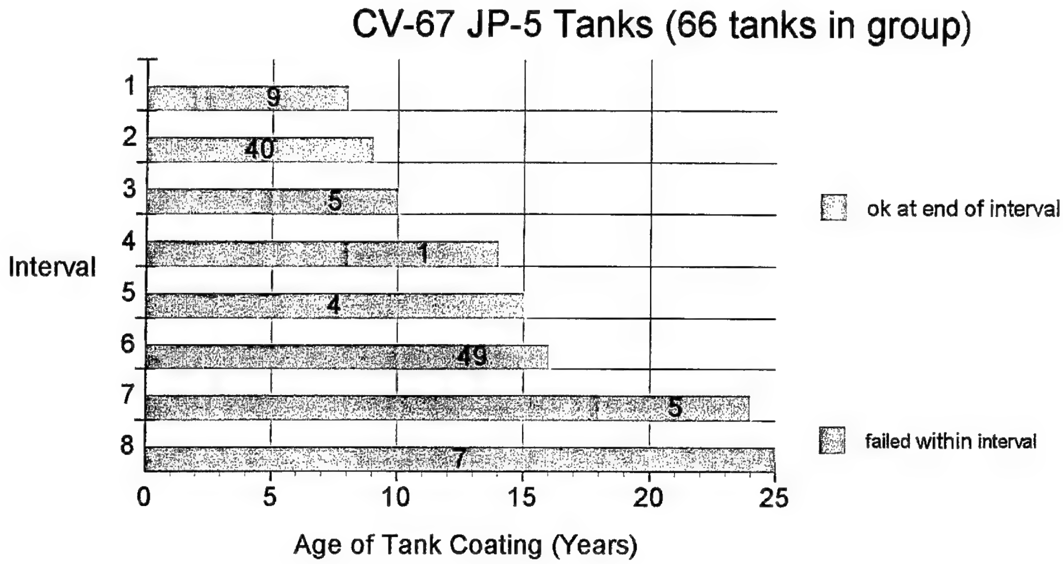
APPENDIX A.9. CVN-65 DRY VOID & COFFERDAM HISTORY FILE

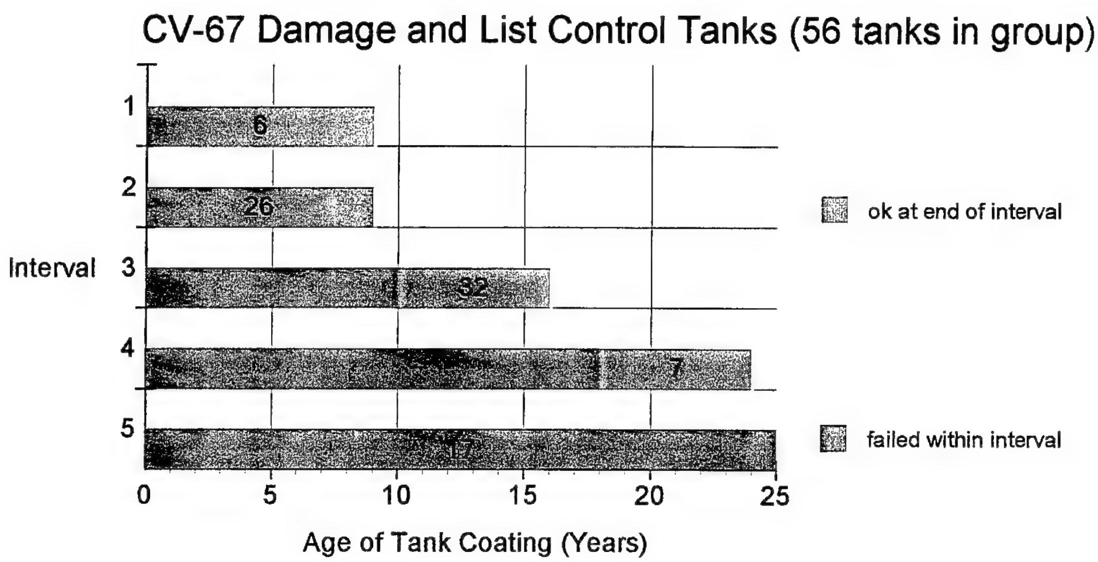
	A	B	C	D	E	F	G	H	I	J
220	SWLIN	SERV	TANK	INS Date	COND	INS Date	COND	PAINTED	COMMENTS	INTERVALS
221	12321	VOID	65-5-205-6-V			23-Oct-91	1-			[0,30)+
222	12321	VOID	65-5-210-2-V			17-Oct-91	0			[0,30]
223	12321	VOID	65-5-32-1-V							
224	12321	VOID	65-5-32-2-V							
225	12321	VOID	65-6-181-1-V							
226	12321	VOID	65-6-181-2-V	12-Apr-95	1					[0,34)+
227	12321	VOID	65-6-186-2-V			17-Oct-91	1			[0,30)+
228	12321	VOID	65-6-186-3-V			17-Oct-91	1			[0,30)+
229	12321	VOID	65-6-186-4-V			21-Oct-91	1-			[0,30)+
230	12321	VOID	65-6-186-5-V			24-Oct-91	1-			[0,30)+
231	12321	VOID	65-6-191-2-V			28-May-92	1			[0,30)+
232	12321	VOID	65-6-191-3-V			16-Sep-91	1-			[0,30)+
233	12321	VOID	65-6-195-5-V			28-May-92	1			[0,30)+
234	12321	VOID	65-6-195-8-V							
235	12321	VOID	65-6-195-9-V							
236	12321	VOID	65-7-183-1-V							
237	12321	VOID	65-7-215-0-V			1-Jun-90	1			[0,30)+
238	12321	VOID	65-7-215-2-V			17-Oct-91	1			[0,30)+
239	12321	VOID	65-7-225-0-V	19-May-95	0	17-Oct-91	0	1991	wrong paint	[0,30]
240	12321	VOID	65-7-225-1-V	19-May-95	1-	17-Oct-91	0	1991	wrong paint	[0,30]
241	12321	VOID	65-7-32-1-V					1994		[0,30]
242	12321	VOID	65-8-115-18-V			17-Jun-91	1-			[0,30)+
243	12321	VOID	65-8-13-0-V			8-Jul-92	0	1994		[0,30]
244	12321	VOID	65-8-137-0-V							
245	12321	VOID	65-8-137-2-V							
246	12321	VOID	65-8-148-11-V					1-Jan-86		[0,25]
247	12321	VOID	65-8-162-16-V					1994		[0,30]
248	12321	VOID	65-8-17-0-V	5-May-95	1	19-May-92	1	1/1/1989, 1991 (SF)	wrong paint, bad shape	[0,30]
249	12321	VOID	65-8-17-1-V			19-May-92	0		bad shape	[0,30]
250	12321	VOID	65-8-17-2-V			19-May-92	1	13-Feb-92		[0,30]
251	12321	VOID	65-8-189-1-V			12-Sep-91	1			[0,30)+
252	12321	VOID	65-8-189-2-V			12-Sep-91	1			[0,30)+
253	12321	VOID	65-8-195-1-V			19-Jul-92	0	1994 (NNS)		[0,30]
254	12321	VOID	65-8-195-2-V			11-Sep-91	0			[0,30]
255	12321	VOID	65-8-195-3-V			12-Jun-92	1			[0,30)+
256	12321	VOID	65-8-195-4-V			19-Jul-92	0	1994 (NNS)		[0,30]
257	12321	VOID	65-8-195-5-V			12-Jun-92		1994		[0,30]
258	12321	VOID	65-8-195-6-V			12-Jun-92		1994		[0,30]
259	12321	VOID	65-8-195-7-V			12-Sep-91	1-	1-Jan-79		[0,18]
260	12321	VOID	65-8-195-8-V			28-May-92		1-Jan-79		[0,18]
261	12321	VOID	65-8-200-1-V			12-Jun-92		1994		[0,30]
262	12321	VOID	65-8-200-2-V			12-Jun-92		1994		[0,30]
263	12321	VOID	65-8-205-1-V			12-Jun-92	1			[0,30)+
264	12321	VOID	65-8-205-10-V			9-Sep-91	1			[0,30)+
265	12321	VOID	65-8-205-12-V			28-May-92	1			[0,30)+
266	12321	VOID	65-8-205-14-V			23-Oct-91	0			[0,30]
267	12321	VOID	65-8-205-2-V			9-Sep-91	0			[0,30]
268	12321	VOID	65-8-205-3-V			11-Sep-91	1			[0,30)+
269	12321	VOID	65-8-205-4-V			9-Sep-91	1			[0,30)+
270	12321	VOID	65-8-205-5-V			19-Jul-92	0	1994		[0,30]
271	12321	VOID	65-8-205-6-V			12-Jun-92	1			[0,30)+
272	12321	VOID	65-8-205-7-V			12-Jun-92	1			[0,30)+
273	12321	VOID	65-8-205-8-V			9-Sep-91	1			[0,30)+
274	12321	VOID	65-8-210-2-V			11-Sep-91	1			[0,30)+
275	12321	VOID	65-8-215-1-V			14-Sep-91	0			[0,30]
276	12321	VOID	65-8-215-2-V			14-Sep-91	1			[0,30)+
277	12321	VOID	65-8-215-3-V			12-Jun-92	1			[0,30)+
278	12321	VOID	65-8-215-4-V			13-Sep-91	1			[0,30)+
279	12321	VOID	65-8-215-6-V			14-Sep-91	1			[0,30)+
280	12321	VOID	65-8-215-8-V			13-Sep-91	0			[0,30]
281	12321	VOID	65-8-22-2-V				1			[0,30)+
282	12321	VOID	65-8-225-1-V			26-May-92	1			[0,30)+
283	12321	VOID	65-8-225-10-V	23-May-95	0	14-Sep-91	1		wrong paint	[0,30]
284	12321	VOID	65-8-225-2-V			26-May-92	1			[0,30)+
285	12321	VOID	65-8-225-3-V	19-May-95	0	14-Sep-91	1		already selected by SF	[0,32]
286	12321	VOID	65-8-225-4-V	19-May-95	1-	14-Sep-91	1-			[0,34)+
287	12321	VOID	65-8-225-5-V	23-May-95	1-	14-Sep-91	0			[0,30]
288	12321	VOID	65-8-225-6-V	7-Jun-95	1	12-Jun-92		1964	wrong paint, cond 3 or 4 under deckplate	[0,30]
289	12321	VOID	65-8-225-7-V	7-Jun-95	1	19-Jul-92	0	1994(NNS)	no change in cond in 3 yrs	[0,30]
290	12321	VOID	65-8-225-8-V	7-Jun-95	1	19-Jul-92	0	1994(NNS)	no change in cond in 3 yrs	[0,30]
291	12321	VOID	65-8-225-9-V	8-Jun-95	1-	13-Sep-91		1994 (SF)	wrong paint	[0,30]
292	12321	VOID	65-8-235-1-V	12-May-95	0	12-Jun-92		1994 (SF)	wrong paint	[0,30]

APPENDIX A.9. CVN-65 DRY VOID & COFFERDAM HISTORY FILE

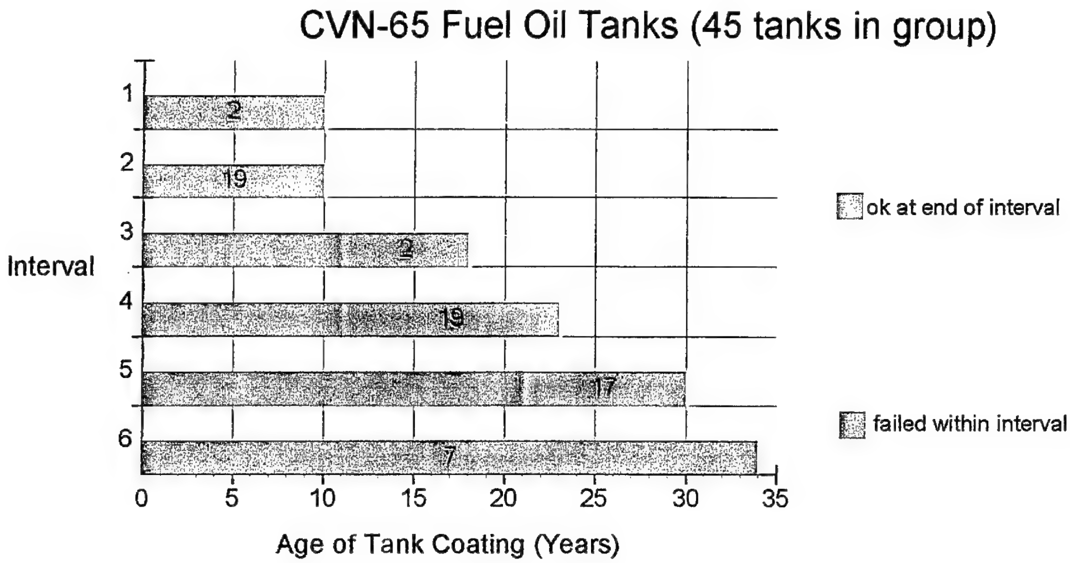
	A	B	C	D	E	F	G	H	I	J
293	SWLIN	SERV	TANK	INS Date	COND	INS Date	COND	PAINTED	COMMENTS	INTERVALS
294	12321	VOID	65-8-235-2-V	12-May-95	1-	13-Sep-91	0	1994 (SF)	wrong paint	[0,30]
295	12321	VOID	65-8-235-3-V	12-May-95	1-	13-Sep-91	1	1994 (SF)	wrong paint, no change in cond in 4 yrs	[0,30]
296	12321	VOID	65-8-235-4-V	12-May-95	1-	13-Sep-91	1	1994 (SF)	wrong paint, no change in cond in 4 yrs	[0,30]
297	12321	VOID	65-8-235-5-V			13-Sep-91	1-			[0,30)+
298	12321	VOID	65-8-235-6-V	12-May-95	1-	13-Sep-91	1	1994 (SF)	wrong paint, no change in cond in 4 yrs	[0,30]
299	12321	VOID	65-8-235-7-V			12-Jun-92	1			[0,30)+
300	12321	VOID	65-8-235-8-V			19-Jul-92	0	1994 (NNS)		[0,30]
301	12321	VOID	65-8-245-1-V	10-May-95	1	13-Sep-91	1-	10/15/1991 (SF)	wrong paint	[0,30]
302	12321	VOID	65-8-245-2-V	10-May-95	1	13-Sep-91	1-	1991 (SF)	wrong paint	[0,30]
303	12321	VOID	65-8-245-3-V	10-May-95	0	13-Sep-91	1-		already selected by SF	[0,32]
304	12321	VOID	65-8-245-4-V	10-May-95	0	13-Sep-91	1		already selected by SF	[0,32]
305	12321	VOID	65-8-245-5-V	10-May-95	1	13-Sep-91	0	1994 (SF)	wrong paint	[0,30]
306	12321	VOID	65-8-245-6-V	11-May-95	1	13-Sep-91	1	10/4/1991 (SF)	wrong paint	[0,30]
307	12321	VOID	65-8-245-7-V	10-May-95	1-	12-Jun-92		1994 (SF)	wrong paint	[0,30]
308	12321	VOID	65-8-245-8-V	10-May-95	1	13-Sep-91	1	1994 (SF)	wrong paint	[0,30]
309	12321	VOID	65-8-250-1-V	10-May-95	1	12-Jun-92		1994 (SF)	wrong paint	[0,30]
310	12321	VOID	65-8-250-2-V	12-May-95	1	12-Jun-92		1994 (SF)	wrong paint	[0,30]
311	12321	VOID	65-8-255-0-V	12-May-95	0	13-Sep-91	0		already selected by SF	[0,30]
312	12321	VOID	65-8-27-2-V				1			[0,30)+
313	12321	VOID	65-8-47-2-V			22-Jun-92	1	1981		[0,18] , [0,10)+
314	12321	VOID	65-8-62-10-V			19-Aug-91	1	1-Jan-90		[0,30]
315	12321	VOID	65-8-62-9-V			29-Jul-92	1			[0,30)+

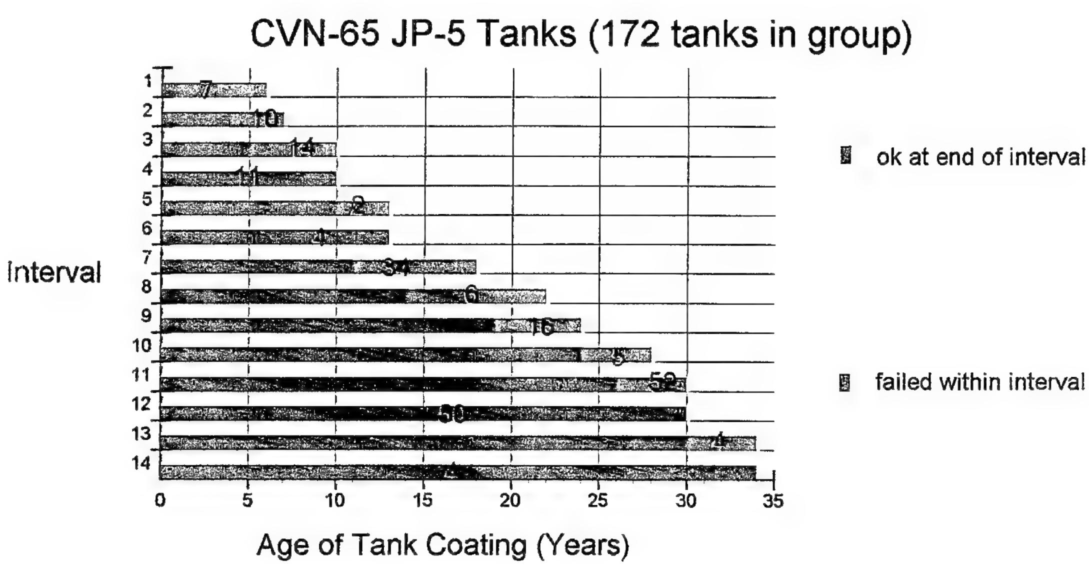
APPENDIX B.1. CV-67 SUMMARY INTERVAL CHARTS



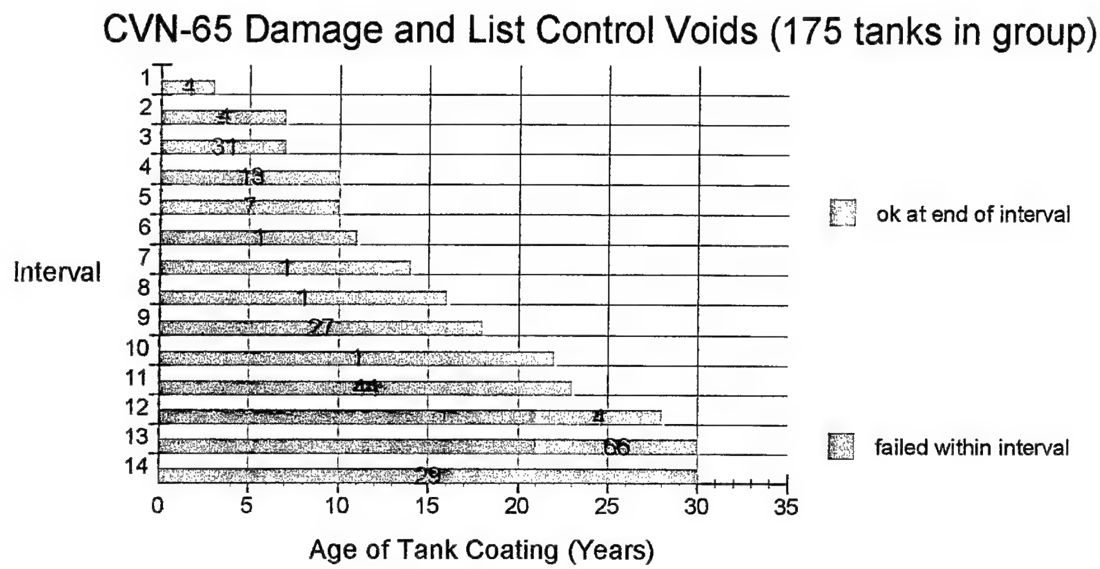


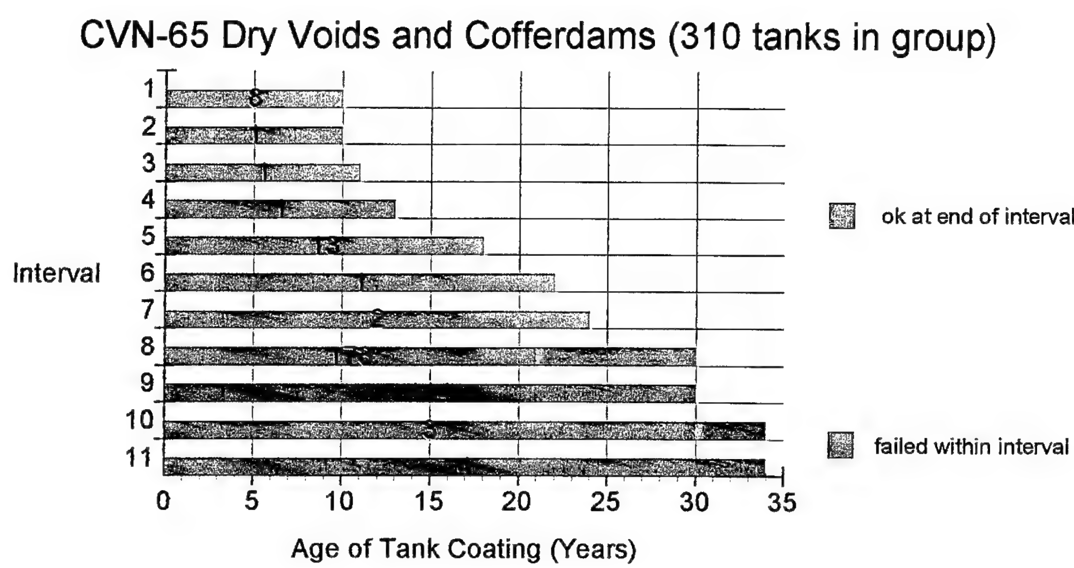
APPENDIX B.2. CVN-65 SUMMARY INTERVAL CHARTS





APPENDIX B.2. CVN-65 SUMMARY INTERVAL CHARTS





APPENDIX C.1. TWO PARAMETER WEIBULL DISTRIBUTION PROPERTIES

The Weibull probability density function (pdf) is:

$$f(t) = \lambda\kappa(\lambda t)^{\kappa - 1} e^{-(\lambda t)^{\kappa}}, \quad t > 0,$$

where λ is the scale parameter, and κ is the shape parameter. Both λ and κ are positive. The Weibull distribution parameters are frequently expressed with the inverse of the scale parameter, $\frac{1}{\lambda} = \alpha$. α is called the "characteristic life", and is approximately the 63.2th percentile (Nelson, 1982). For the special case $\kappa = 1$, the Weibull reduces to the simple exponential. For shape parameters $3 \le \kappa \le 4$, the Weibull's shape resembles the normal distribution.

The Weibull cumulative distribution function (cdf) is:

$$F(t) = 1 - e^{-(\lambda t)^{\kappa}}, \quad t > 0.$$

The conjugate cdf is also the survivor function *S(t)*. Thus the reliability at time *t* can be expressed as:

$$S(t) = e^{-(\lambda t)^{\kappa}}, \quad t > 0.$$

The Weibull hazard function (failure rate), instantaneous failure rate at any age *t*, is:

$$h(t) = \frac{f(t)}{S(t)} = \lambda\kappa(\lambda t)^{\kappa - 1}, \quad t > 0.$$

For values of $\kappa > 1$, the Weibull will have an increasing failure rate, and decreasing for $\kappa < 1$.

The Weibull distribution has mean:

$$E(T) = \alpha \Gamma[1 + (1/\kappa)],$$

and variance:

$$Var(T) = \alpha^2 \{\Gamma[1 + (2/\kappa)] - \{\Gamma[1 + (1/\kappa)]\}^2\},$$

where Γ is the complete gamma function.

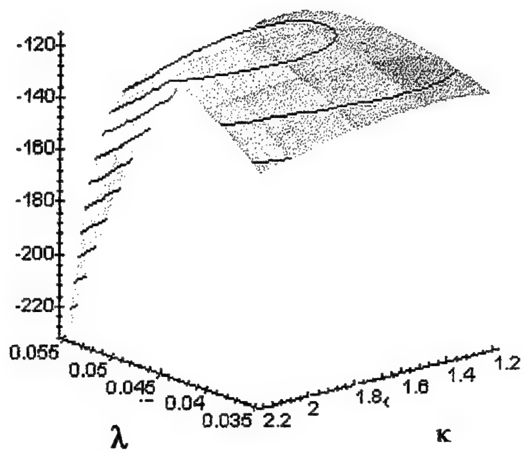
APPENDIX C.2. EXAMPLE MAPLE CODE FOR MLE (CVN-65 JP-5 GROUP)

```
> a:=(exp(-(4*la)^k) - (exp(-(7*la)^k)))^10:
> simplify(a):
> aa:=log("):
> simplify(aa):
> diff(",la):
> aaa:=simplify("):
> b:=(exp(-(5*la)^k) - (exp(-(10*la)^k)))^14:
> simplify(b):
> bb:=log("):
> simplify(bb):
> diff(",la):
> bbb:=simplify("):
> c:=(exp(-(10*la)^k) - (exp(-(13*la)^k)))^2:
> simplify(c):
> cc:=log("):
> simplify(cc):
> diff(",la):
> ccc:=simplify("):
> d:=(exp(-(14*la)^k) - (exp(-(18*la)^k)))^34:
> simplify(d):
> dd:=log("):
> simplify(dd):
> diff(",la):
> ddd:=simplify("):
> e:=(exp(-(14*la)^k) - (exp(-(22*la)^k)))^6:
> simplify(e):
> ee:=log("):
> simplify(ee):
> diff(",la):
> eee:=simplify("):
> f:=(exp(-(19*la)^k) - (exp(-(24*la)^k)))^16:
> simplify(f):
> ff:=log("):
> simplify(ff):
> diff(",la):
> fff:=simplify("):
> g:=(exp(-(24*la)^k) - (exp(-(28*la)^k)))^5:
> simplify(g):
> gg:=log("):
> simplify(gg):
> diff(",la):
> ggg:=simplify("):
> h:=(exp(-(26*la)^k) - (exp(-(30*la)^k)))^52:
> simplify(h):
> hh:=log("):
> simplify(hh):
> diff(",la):
> hhh:=simplify("):
> j:=(exp(-(30*la)^k) - (exp(-(34*la)^k)))^4:
```

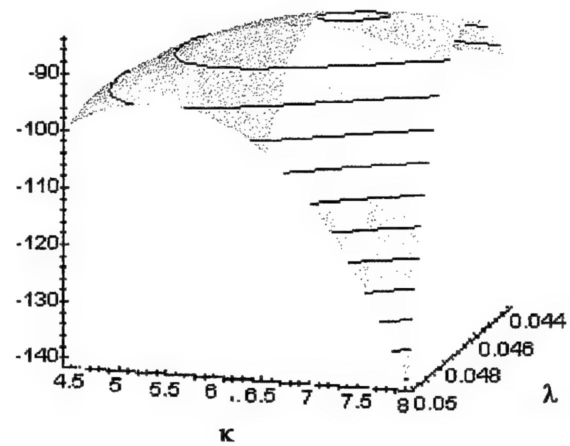
```
> simplify(j):
> jj:=log("):
> simplify(jj):
> diff(",la):
> jjj:=simplify("):
> diff(aa,k):
> ppp:=simplify("):
> diff(bb,k):
> qqq:=simplify("):
> diff(cc,k):
> rrr:=simplify("):
> diff(dd,k):
> sss:=simplify("):
> diff(ee,k):
> ttt:=simplify("):
> diff(ff,k):
> uuu:=simplify("):
> diff(gg,k):
> vvv:=simplify("):
> diff(hh,k):
> www:=simplify("):
> diff(jj,k):
> xxx:=simplify("):
> exp(-(6*la)^(7*k))*exp(-(10*la)^(11*k))*exp(-(13*la)^(4*k))*exp(-
(30*la)^(50*k))*exp(-(34*la)^(4*k)):
> log("):
> lnrtcensored:=simplify("):
> lncensordla:=diff(",la):
> partiallnLdla:=lncensordla+aaa+bbb+ccc+ddd+eee+fff+ggg+hhh+jjj:
> diff(lnrtcensored,k):
> lncensordk:=simplify("):
> partiallnLdk:=lncensordk+ppp+qqq+rrr+sss+ttt+uuu+vvv+www+ xxx:
> partiallnLdk:=simplify(")
> partial2lnLdla2:=diff(partiallnLdla,la):
> partial2lnLdk2:=diff(partiallnLdk,k):
> mixedpartiallnLdlak:=diff(partiallnLdk,la):
> lnL:=lnrtcensored+ aa + bb + cc + dd + ee + ff + gg + hh + jj:
> subs(la=0.0334,k=2.360,partiallnLdla):
> firstpartialla:=evalf(");
> subs(la=0.0334,k=2.360,partiallnLdk):
> firstpartialk:=evalf(");
> subs(la=0.0334,k=2.360,partial2lnLdla2):
> secondpartialla:=evalf(");
> subs(la=0.0334,k=2.360,partial2lnLdk2):
> secondpartialk:=evalf(");
> subs(la=0.0334,k=2.360,mixedpartiallnLdlak):
> mixedpartial:=evalf(");
> solve({-(secondpartialla)*a1 - (mixedpartial)*b1= firstpartialla,-
(mixedpartial)*a1- (secondpartialk)*b1=firstpartialk}, {a1,b1});
> subs(la=0.0334,k=2.360,lnL):
> evalf(");
```

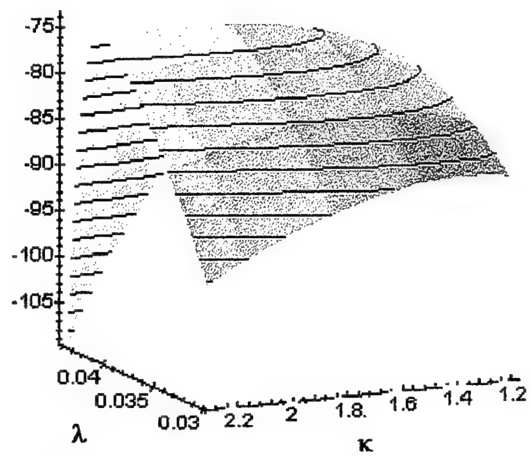
APPENDIX C.3. CV-67 GROUP MAXIMUM LIKELIHOOD PLOTS

CV-67 JP-5 Tanks



CV-67 Fuel Oil Tanks



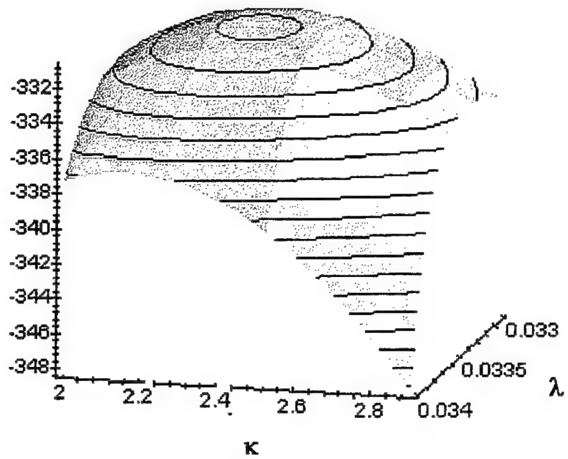


CV-67 Damage and List Control Voids

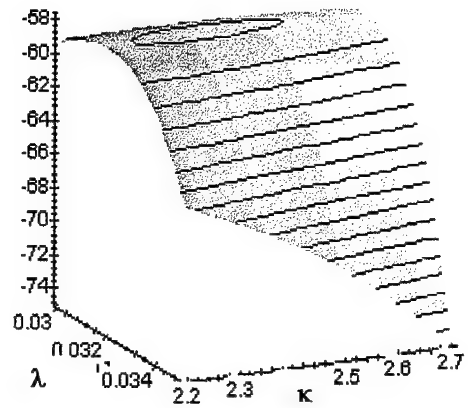
Log Likelihood is plotted against the two Weibull parameters (λ, κ)

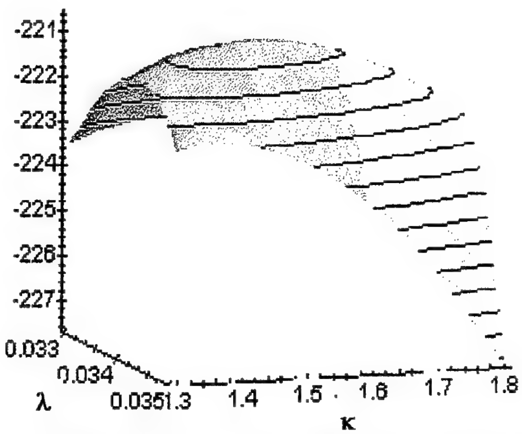
APPENDIX C.3. CVN-65 GROUP MAXIMUM LIKELIHOOD PLOTS

CVN-65 JP-5 Tanks

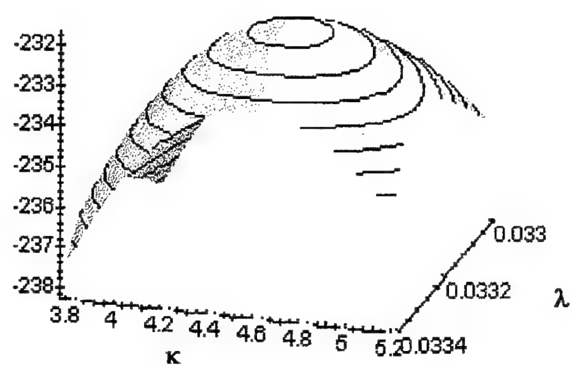


CVN-65 Fuel Oil Tanks





CVN-65 Damage and List Control Voids

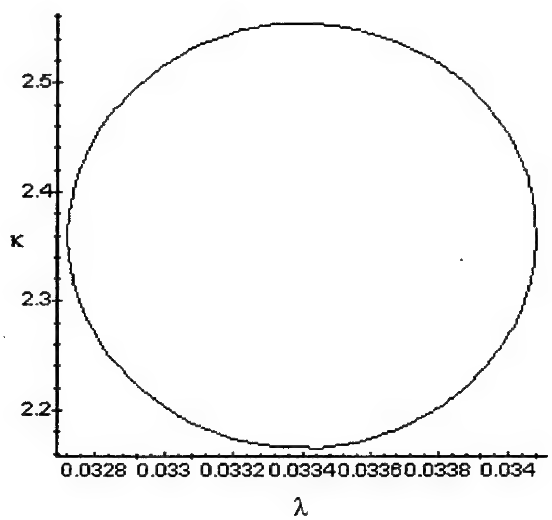


CVN-65 Dry Voids and Cofferdams

Log Likelihood is plotted against the two Weibull parameters (λ, κ)

APPENDIX C.4. EXAMPLE MAPLE CODE FOR OBTAINING JOINT CONFIDENCE REGIONS (CVN-65 JP-5 GROUP)

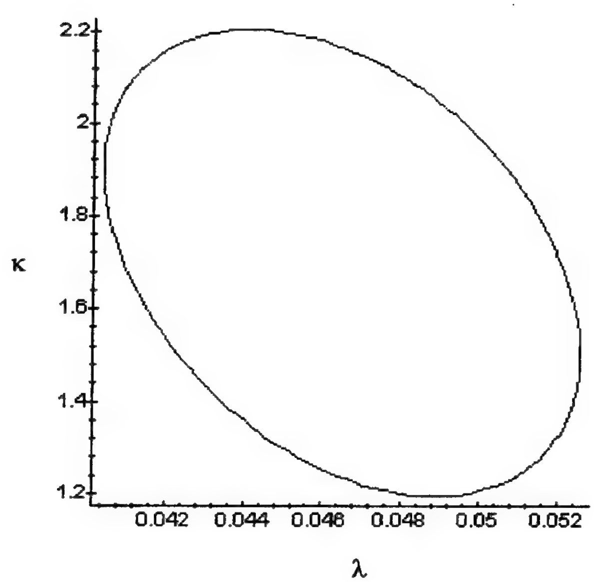
```
> first:=array(1..2,1..1):
> first[1,1]:=0.0334-b1:
> first[2,1]:=2.36-b2:
> second:=array(1..2,1..2):
> second[1,1]:=1.64*10^7:
> second[1,2]:=31.683:
> second[2,1]:=31.683:
> second[2,2]:=199.64:
> with(linalg):
> multiply(transpose(first),second):
> multiply(",first):
>f:=(547834.7719-16400.00*b1-31.683*b2)*(.334e-1-b1)+(472.2086 -
     31.683*b1-199.64*b2)*(2.36-b2):
> ff:=expand(f):
> subs(b2=2.360,ff):
> solve("=7.588,b1):
> subs(b1=0.0334,ff):
> solve("=7.588,b2):
> with(plots):
implicitplot(ff=7.588,b1=0.032..0.035,b2=2.1..2.6);
```



Circular joint confidence region illustrates approximately no correlation between parameters.

APPENDIX C.4. EXAMPLE MAPLE CODE FOR OBTAINING JOINT CONFIDENCE REGIONS (CV-67 JP-5 GROUP)

```
> first:=array(1..2,1..1):
> first[1,1]:=0.0465-b1:
> first[2,1]:=1.70-b2:
> second:=array(1..2,1..2):
> second[1,1]:=2.529*10^5:
> second[1,2]:=1201.12:
> second[2,1]:=1201.12:
> second[2,2]:=36.121:
> with(linalg):
> multiply(transpose(first),second):
> multiply(",first):
>f:=(13801.75400-252900.000*b1-1201.12*b2)*(.465e-1-b1)
    +(117.257780-1201.12*b1-36.121*b2)*(1.70-b2):
> ff:=expand(f):
> subs(b2=1.70,ff):
> solve("=7.80,b1):
> subs(b1=0.0465,ff):
> solve("=7.80,b2):
> with(plots):
implicitplot(ff=7.80,b1=0.0400..0.0530,b2=1.15..2.25);
```



Elliptical joint confidence region illustrating a higher degree of correlation in the variance of the parameters than in the previous circular plot for CVN-65 JP-5 tank group.

APPENDIX D. SURVIVAL FUNCTIONS (FUEL OIL GROUPS)

CVN - 65 Fuel Oil Tanks: $\hat{\lambda} = 0.0317, \hat{\kappa} = 2.40$, Mean Life = 27.96 years

95% Confidence Intervals :

$$[0.0289 \leq \lambda \leq 0.0345]$$

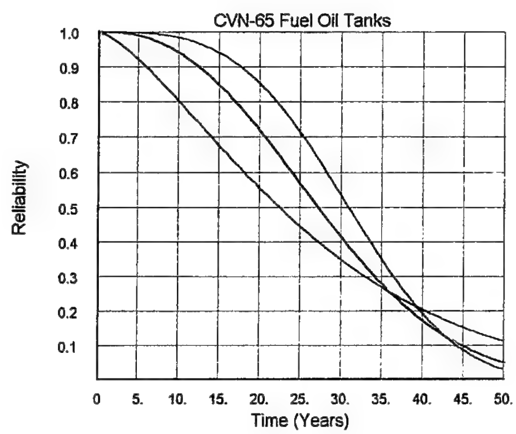
$$[1.43 \leq \kappa \leq 3.36]$$

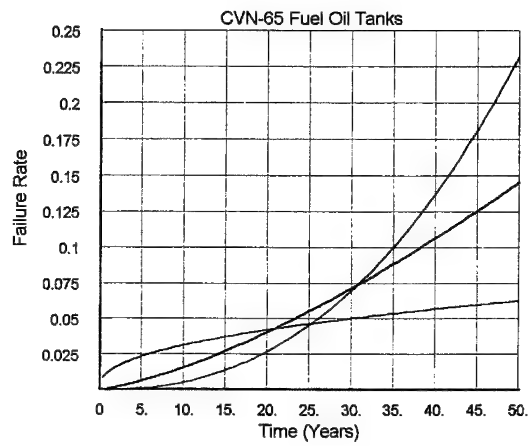
Two parameter Weibull plots

λ = 0.0345
κ = 1.43

λ = 0.0317
κ = 2.40

λ = 0.0289
κ = 3.36





CV - 67 Fuel Oil Tanks: $\hat{\lambda} = 0.0468, \hat{\kappa} = 6.91$, Mean Life = 19.97 years

95 % Confidence Intervals:

$$[0.0453 \leq \lambda \leq 0.0483]$$

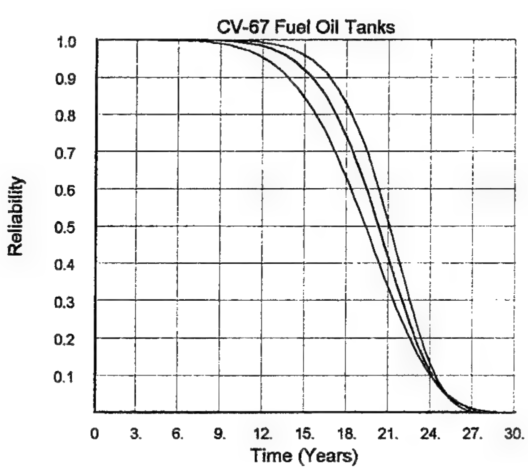
$$[5.55 \leq \kappa \leq 8.27]$$

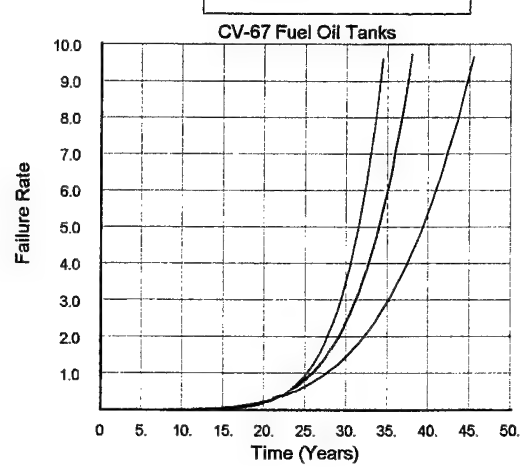
Two parameter Weibull plots:

λ = 0.0483
κ = 5.55

λ = 0.0468
κ = 6.91

λ = 0.0453
κ = 8.27





APPENDIX D. SURVIVAL FUNCTIONS (JP-5 GROUPS)

CVN - 65 JP - 5 Tanks: $\hat{\lambda} = 0.0334, \hat{\kappa} = 2.36$, Mean Life = 26.53 years

$$[0.0327 \leq \lambda \leq 0.0341]$$

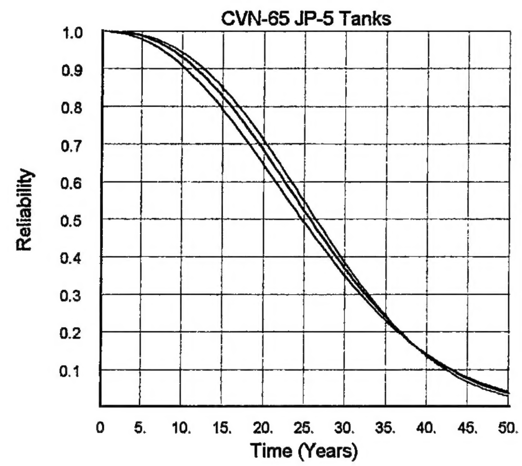
$$[2.17 \leq \kappa \leq 2.55]$$

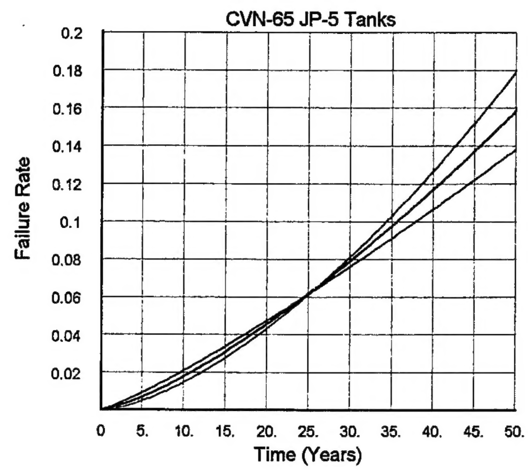
95% Confidence Intervals :
Two parameter Weibull plots

$\lambda = 0.0341$
$\kappa = 2.17$

$\lambda = 0.0334$
$\kappa = 2.36$

$\lambda = 0.0327$
$\kappa = 2.55$





CV - 67 JP - 5 Tanks: $\hat{\lambda} = 0.0465, \hat{\kappa} = 1.70$, Mean Life = 19.19 years

$$[0.0409 \leq \lambda \leq 0.0521]$$

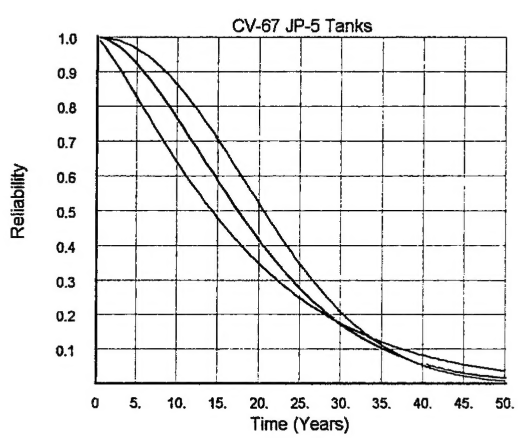
$$[1.24 \leq \kappa \leq 2.16]$$

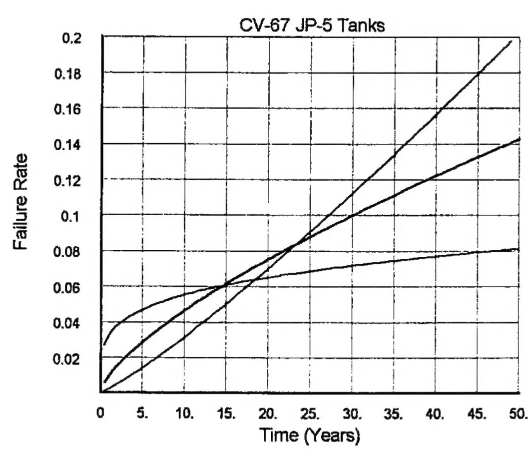
95 % Confidence Intervals:
Two parameter Weibull plots:

$\lambda = 0.0521$
$\kappa = 1.24$

$\lambda = 0.0465$
$\kappa = 1.70$

$\lambda = 0.0409$
$\kappa = 2.16$





APPENDIX D. SURVIVAL FUNCTIONS (DC & LC VOID GROUPS)

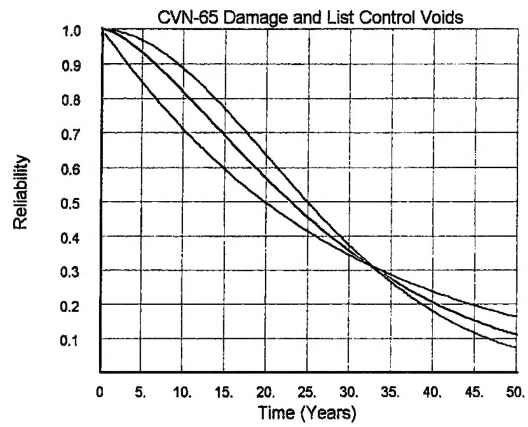
CVN - 65 Damage and List Control Voids: $\hat{\lambda} = 0.0342, \hat{\kappa} = 1.48$, Mean Life = 26.44 years

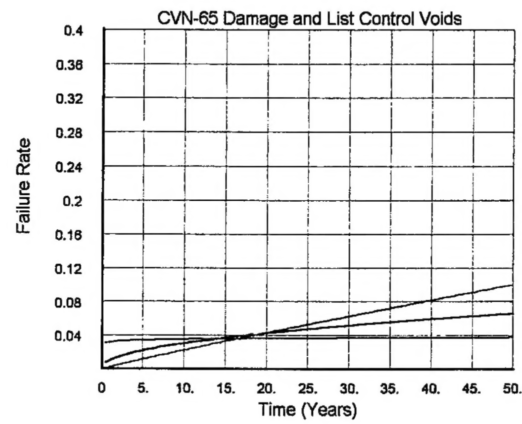
95% Confidence Intervals :
Two parameter Weibull plots

$$[0.0330 \leq \lambda \leq 0.0354]$$

$$[1.04 \leq \kappa \leq 1.92]$$

λ = 0.0354 κ = 1.04	———
λ = 0.0342 κ = 1.48	———
λ = 0.0330 κ = 1.92	———





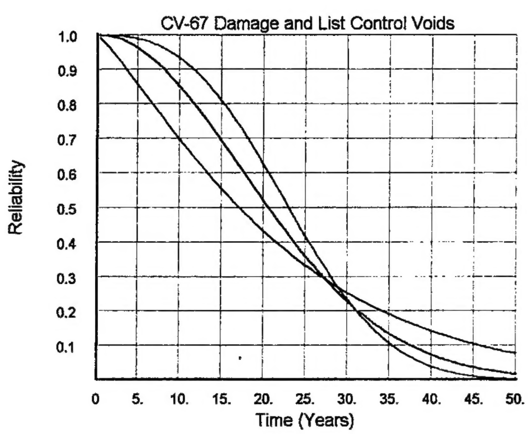
CV - 67 Damage and List Control Voids: $\hat{\lambda} = 0.0406, \hat{\kappa} = 2.00$, Mean Life = 21.83 years

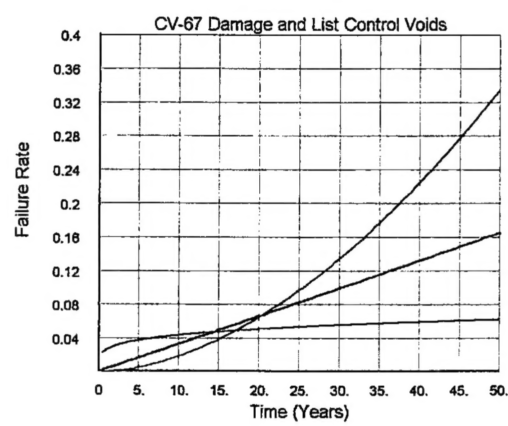
95 % Confidence Intervals:
Two parameter Weibull plots:

$$[0.0380 \leq \lambda \leq 0.0432]$$

$$[1.22 \leq \kappa \leq 2.79]$$

λ = 0.0432 κ = 1.22	———
λ = 0.0406 κ = 2.00	———
λ = 0.0453 κ = 2.79	———





APPENDIX D. SURVIVAL FUNCTIONS (DRY VOID GROUPS)

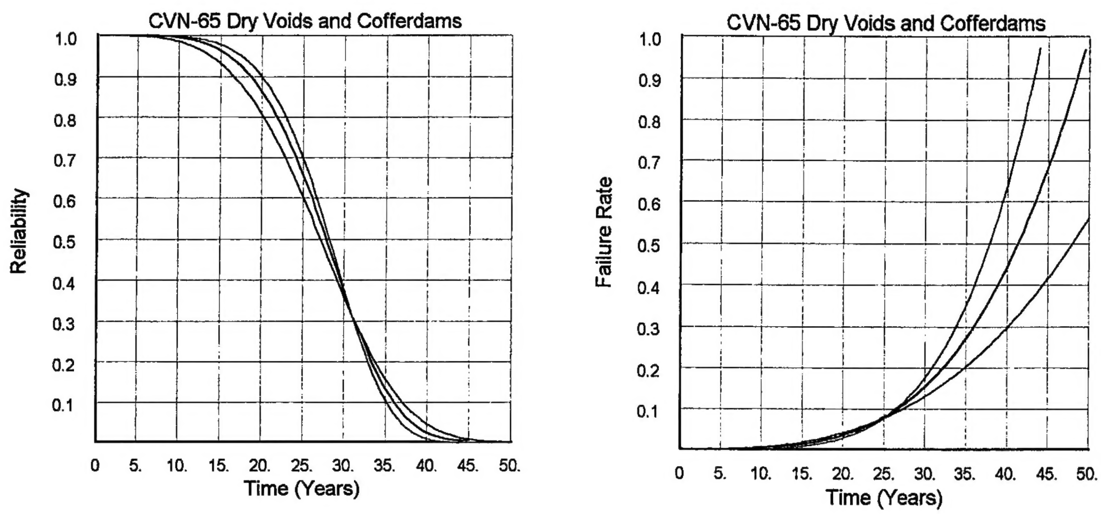
CVN - 65 Dry Voids and Cofferdams: $\hat{\lambda} = 0.0333, \hat{\kappa} = 4.66$, Mean Life = 27.46 years

$$[0.0331 \leq \lambda \leq 0.0335]$$

$$[3.85 \leq \kappa \leq 5.47]$$

95% Confidence Intervals :
Two parameter Weibull plots

$\lambda = 0.0335$ $\kappa = 3.85$	———
$\lambda = 0.0333$ $\kappa = 4.66$	———
$\lambda = 0.0331$ $\kappa = 5.47$	———



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